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ABSTRACT

Since the early 1980s, many reports have appealed for improvement in science and mathematics education in the schools. Even when new and/or supplementary materials are provided and made available to teachers, natural inertia is difficult to overcome. This document reports on the status of science and mathematics education improvement in three states: Colorado, Ohio, and North Carolina. An overview of the project is presented by Anne Lewis. The reports of three journalists: Jim Wright (The Rocky Mountain News); Kathy Foster (The Columbus Dispatch); and David Perkins (Raleigh News and Observer) are presented in this document. The project itself, rural schools, teacher education, teacher qualifications, elementary schools, attracting women and minorities, teacher shortages, teaching innovations, and math-science networks are discussed. The appendices provide news stories based on two of the reports, as well as a list of assessment project questions. (CW)

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PUSHING A BOULDER UPHILL

THREE REPORTERS VIEW

STATE PROGRESS IN MATH/SCIENCE EDUCATION

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FOREWORD

This publications stems from a question Standard Oil/BP America asked the Institute for Educational Leadership several years ago:

> "What is the most effective mechanism to motivate large numbers of educators across the country to use new materials?"

We wanted an answer because Standard Oil/BP America, in response to a national clamor for reforming science education, had just made a major grant to the American Association for the Advancement of Science for development of "hands on" science materials for junior high school use. AAAS would develop Science Resources for Schools, designed to replace -- or supplement -- textbook-only teaching.

We were convinced there were good activity-based science materials available around the nation, in addition to the AAAS packets under development. We wanted to document possible dissemination techniques to facilitate the sharing of those materials and influence how teachers teach science.

Like the rest of us, teachers don't necessarily adopt the new, even when it is demonstrably better than what is currently in use. Natural inertia is difficult to overcome, particularly with teachers who are overworked and underappreciated. The crush of their work schedules often gives them little time to prepare for science instruction and compounds the discomfort that many teachers feel about science in the first place.

The original task -- to document the process of introduction of Science Resources for the Schools in three states (Colorado, North Carolina, and Ohio) -- changed as time elapsed. We agreed that a broader look at changes in science and math instruction since the alarm of A Nation at Risk in 1983 would be more broadly appealing and still provide a look at science in these states.

When I read the report, I was excited by its potential value to others who may want to be part of -- or have access to -- a state science network. I made a number of valuable discoveries about how the system works in Ohio, a system I already thought I knew fairly well.

I hope this report will serve as a road map for others, illustrating the variety and complexity of science networks and how they work in these specific cases. Perhaps others will be tempted to finish this work and document the process in the remaining 47 states.

-- Sondra Hardis
Senior Contributions Analyst
Standard Oil/BP America
October 1987

INTRODUCTION

This report was completed as part of a grant to the Institute for Educational Leadership from the Standard Oil/BP America to support initiatives in math and science education in the states of Colorado, North Carolina and Ohio. In the summer of 1986, the Education Writers Association contracted with the Institute for Educational Leadership to produce a monograph on math and science education in the three states. What had happened in the three intervening years since release of *A Nation At Risk* and the report of the National Science Board, *Educating Americans for the 21st Century*?

EWA asked freelance writer Anne Lewis, former editor of *Education USA*, to coordinate the project and to identify reporters from newspapers in the three states to take a look at how each state and its school districts had responded to the calls for change and to examine how the states were responding to the need for qualified teachers. The reporters were provided a set of common questions for guidance, were contacted frequently by Anne during the project, and were encouraged to run the resulting stories in their newspapers.

Thanks to Anne Lewis, Jim Wright of *The Rocky Mountain News*, Kathy Foster of *The Columbus Dispatch* and David Perkins of the Raleigh *News and Observer* for their insightful reporting. Two of the papers ran the series as stories, although in altered form. The stories are printed in the appendix of this volume.

Thanks also to Sondra Hardis of the Standard Oil/BP America for her support and forbearance over the years of this project.

-- L. W.

PUSHING A BOULDER UPHILL

THREE REPORTERS VIEW

STATE PROGRESS IN MATH/SCIENCE EDUCATION

Anne C. Lewis, freelance writer and Washington correspondent, *Phi Delta Kappan*

OVERVIEW

More than four years ago, a brief report, *A Nation at Risk*, alarmed policy-makers and the public in general about the condition of American public schooling. Produced by a federally appointed national commission after 18 months of hearings and research, it resulted in numerous other studies and individual state actions. The primary result, however, was to illuminate major problems in pre-collegiate education and involve important "actors" in developing plans for improvement, especially governors and business leaders.

At the same time this national commission was examining the state of pre-collegiate education broadly, another group conducted a lengthy study of one particular weakness of American education--math and science instruction. The report of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology appeared several months after *A Nation at Risk*. While the latter painted a broad picture of problems and efforts needed, the science board's commission report, *Educating Americans for the 21st Century*, focused on one area of the curriculum, with specific recommendations that it hoped would raise American student achievement to the best in the world by 1995.

Its findings were as alarming as those of *A Nation at Risk*, for anyone interested in the special fields of math and science education. It noted that a very small percentage--no more than 5%--of American students were receiving an adequate education in math and the sciences, at a time when the nation's productivity and society's ability to cope with problems increasingly depended on a solid understanding of math and sciences by the general public.

In 1982 science achievement scores of students were lower than in 1970, according to data from the National Assessment of Educational Progress. The 10th grade is the last time most high school students take a science course. Further, American students receive only one-half to one-third the amount of science instruction as high school students in Japan, Germany, East Germany and the Soviet Union. (International comparisons on math achievement released in 1986 found the achievement of American students "among the lowest of any industrialized nation.")

The commission proposed, essentially, a national campaign to improve math/science instruction. By September 1985, all secondary students should be required to take at least three years of mathematics and science/technology, the commission said. It asked for an initial federal investment of $1.51 billion to recruit and retrain teachers, develop curriculum materials and provide equipment.

By September 1985, only 10 states met the recommendations of the commission. For fiscal year 1985, the Administration requested $39 million for precollegiate education programs, an amount increased by Congress to $75 million. Not until January 1987 did the National Science Foundation announce a significant effort to improve the quality of science curricula at the elementary school level, where researchers and educators alike admit a lifelong interest in science begins--and instruction is the weakest. NSF granted $6.6 million to three demonstrations of networks to improve instruction--among textbook publishers, school districts and scientific institutions.

A sweeping reform of math/science education was off to a slow start.

Nonetheless, hardly any state ignored the warnings of the science board commission and other studies. State reform studies and reports recognized the severity of the problem. The quickest solution was to increase high school graduation requirements. Many introduced scholarships or other incentives to teachers or future teachers in the math and science fields.

Yet, state reformers encountered some of the same dilemmas as federal efforts to improve math and science instruction. Policies, commitment and even additional money focused on a specific problem can, at best, provide incremental improvement. To address a major problem involving resources (textbooks), upgrading of teacher training, changing of teacher attitudes, and community priorities requires an understanding of the complexity of the issue--and adequate leadership and resources to do something about it.

This is what education reporters for newspapers in three states found when they attempted to assess the impact of demands for reform in science instruction.

THE PROJECT

Colorado, Ohio and North Carolina represent a cross-section of the states geographically. They also span the degrees of centralized control over public schools. Colorado is what might be called a low-control state, with the state department of education prodding more than requiring change. Its 177 school districts exercise almost complete authority over the schools, setting their own graduation requirements and curriculum.

Ohio is in the middle, providing 46.3 percent of support for the schools and given some authority for mandates in the state's 616 school districts.

North Carolina, at the other end of the spectrum, is considered a high-control state. Not only does the state level provide 64.2 percent of funding for the public schools, but the state department of public instruction has authority to set graduation requirements, develop curriculum guidelines and require testing that determines if teachers are following the curriculum.

Because of these differences, the responses to demands for improved science instruction from policymakers and the public took different paths. However, the reporters found some common frustrations:

- **Data on achievement, enrollments and teacher qualifications often were hard to come by at the state level. While the states admitted to problems in science instruction, they could not always produce the information needed for policymaking.**

James Wright of the *Rocky Mountain News* wrote: "Under the state's strict

local control system, school districts are required to report little back to the state," although he was able to find data by looking at the forms used by the state education department for applications for federal grants.

Kathy Foster of the *Columbus Dispatch* found "the department of education could not provide information on how many high schools offer higher level math and science courses." Further, because in the past Ohio has had no program of statewide testing, "it is difficult to measure whether its students have gotten worse, better, or stayed the same in math and science over the last 10 years."

Combining the resources of the state department of public instruction and the higher education system, David Perkins, formerly of the *News and Observer* at Raleigh, N.C., obtained good statistics. There were some gaps, however. The state education department, for example, did not have current figures on how many teachers held emergency certificates.

- **State leadership was well aware of the problems in science and math education but sometimes unable or unwilling to move quickly on reforms.**

While Ohio's legislature moved on increasing graduation requirements, the lack of teachers and resources reduced the action to a small move. Beginning with the graduating class of 1988, reported Kathy Foster, high school students must take two years of mathematics instead of one as previously required, but they still will need only one year of science. Similarly, the state changed teacher certification requirements but left preparation in math and science unchanged for elementary teachers. Currently, Ohio teachers average only two or three college science courses.

A shortage of money because of the oil bust, rather than inertia, is blamed for what some Colorado educators, interviewed by Jim Wright, described as slippage in science and math instruction. What reforms have been undertaken have been financed with relatively little new money, according to a state school board association official. If anything, he said, money has been diverted from math and science to apply to a renewed interest in foreign languages. Of 123 pilot projects focused on school improvement and funded by the state, only one, an incentive pay plan for teachers, involved either math or science--and it was abandoned after one year, Wright reports.

- **Despite major state-level initiatives in curriculum development and high school graduation requirements, North Carolina faces the problem of a teacher shortage. Spot shortages of math and science teachers already exist in the state's more rural areas, and shortages are predicted statewide if current teacher enrollment patterns continue. The state's lateral entry plan, to draw potentially good math and science teachers from the private sector, hasn't shown success yet. Of the 163 teachers hired under the plan, David Perkins reported, only 34 filled math and science vacancies.**

Further, while new state requirements considerably reduced the number of North Carolina teachers assigned out of field, the certification process is weak. According to Perkins' research, "one-third of the state's science teachers, and most of the physics and chemistry teachers, hold comprehensive science certificates, a general category that allows teachers to teach any science in grades 9-12."

- **Teacher quality is as much, if not more, of a problem as teacher supply.**

Ohio's supply of math and science teachers has kept pace with demand, according to state school officials, because school enrollments have dropped considerably. The percentage of newly graduated teachers needed is growing temporarily, and the largest percentage of teachers assigned out of field is in the math/science fields, but both of these problems are considered minimal by state officials, Kathy Foster found. Yet, it will be four years before higher teacher preparation mandates will begin to be felt in classrooms. An increase in the number of hours required for a math or science teaching certificate, from 20 to 30 hours, took place in July 1987 (although higher education campuses usually have required more hours than the minimum).

In Colorado, the state department of education, which certifies teachers, found 21 percent of the districts had hired at least one teacher without a valid certificate; 47 percent hired at least one high school teacher unqualified for the subject area. While the state enjoys a surplus of teachers generally, it is short of math teachers, 19 percent currently, which will grow to 37 percent by the year 2000. A shortage of science teachers won't appear until that year. Most of the shortages will be at the elementary school level.

North Carolina faces an acute shortage of teachers, not because of decreasing teacher education enrollments, but because of ambitious plans to hire 11,000 new teachers by 1992 to reduce class size and teach an expanded curriculum. A January 1986 survey found 20 percent of the school districts already with a critical need for either math or science teachers. Unless education schools "suddenly are flooded with students," David Perkins wrote, the state will suffer from a "severe" shortage of math teachers and a less serious shortage of science teachers.

Enrollment of math and science education majors actually has pulled out of a decline, Perkins found, but the latest study of those graduates found 30 percent of science teachers drop out during or immediately after their first year of teaching, often grabbed off by higher paying industry jobs, according to state officials.

- **Rural schools present particular problems with curriculum and teacher supply.**

Nearly one-half of Ohio's high schools, 346, have fewer than 500 students, and 147 of them have fewer than 300 students. "This means," Kathy Foster wrote, "they often can't afford or have the necessary number of students to offer advanced math and science courses on a yearly basis." Teachers in small towns and rural areas need to be experts in all the sciences, while teachers at larger schools can be specialists, she added. Recruiting teachers for small schools often is difficult, according to a state education official, because they must teach such a variety of courses and smaller districts often don't pay as well as larger ones.

"Well trained high school math teachers are in short supply in the state's 41 school districts that have fewer than 600 students," Jim Wright reported about Colorado. Less than one-half of the math teachers meet the minimum educational requirements. For science teachers, about 60 percent of the rural districts meet the state standard, compared to 82 percent for the state as a whole.

According to the math and science coordinator at Greeley, who also is a member of the state's science education task force, small school districts typically hire a teacher qualified, for example, to teach biology, then add chemistry and

physics to the workload because the teacher is the only one available. "In some cases, a young teacher may be two pages ahead of the kids in the textbook," he is quoted as saying.

At a special "summer camp" to upgrade the skills of rural math and science teachers in 1986, the best of the teachers in the science program had no more than two college courses in science.

Low pay, as little as $12,000 a year, is blamed for the inability to recruit math and science teachers to rural areas, although this isn't consistent. Highly desirable living areas, such as ski resorts, can attract teachers despite low salaries.

North Carolina's major problem in rural areas centers on teacher supply, with most of the "critical need" for math and science teachers reported from the rural mountain and coastal counties, according to David Perkins.

- **Low performance/enrollment of minorities and girls in math and science courses.**

Ohio's statistics on the performance of girls and blacks on nationally standardized tests in science and math pattern the rest of the country. They score consistently lower than boys and whites. Ohio state education officials point out that boys outnumber girls by nearly two-to-one in computer science courses, while 80 percent of the students training for low-paying, dead-end high tech jobs are girls, Kathy Foster reported.

Colorado's first statewide achievement test, administered in the spring of 1987, "revealed disturbingly low scores for minority students," according to Jim Wright. The greatest disparity showed up in the 11th grade where blacks scored in the 31st percentile in math and 37th percentile in science, compared to the scores of white students--63rd percentile in math and 69th percentile in science.

A survey by the state department of education found that boys dominate enrollments in science and math, even though the male-female ratio in Colorado's schools is exactly even, Wright wrote. Boys account for 72 percent of the enrollments in advanced computer courses and 62 percent of the enrollments in physics and calculus.

A Math-Science Network in North Carolina is focusing on a program to enhance instruction of minorities and women in math and science. These two groups are "seriously underrepresented in advanced high school math and science classes," David Perkins reported.

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In each of the three states, the reporters learned all is not gloom. Positive, successful efforts are underway to improve math and science instruction.

Interestingly, all of the reporters discovered the leverage to produce such changes often comes from higher education institutions.

In Colorado, the legislature ended the elementary education degree, specifying that teacher certification candidates must have a broad liberal arts education. Some smaller regional colleges lost their graduate education programs, and teacher candidates must pass a standardized test, maintain a 2.5 grade point average and spend significantly more time in classroom observation or practice teaching. All teacher candidates must have completed two years of college-preparatory math. Wright also found that college faculty were developing more links with schools.

In another innovative, campus-based effort, those entering teaching in mid-career years at the University of Northern Colorado who will become math and science teachers spend twice as much time in student teaching as other teacher candidates, while their time in class lectures is minimized.

Ohio, likewise, has used teacher preparation programs to reform the training of teachers in science and math, increasing the number of courses required for those planning to teach either subject.

The University of North Carolina system required fall 1988 entering freshmen to have taken three years each of science and math. Previously, each campus set its own admission requirements, and few required as many credits as the new mandate. Further, all new teacher candidates must have a major in a basic academic subject in addition to education. The general, and admittedly unchallenging, courses called "Science for Teachers" and "Math for Teachers" taught in some education schools will be replaced by courses taught by the science and math departments.

Also in North Carolina, the university system's Math-Science Network, funded by the state, is conducting research and sponsoring teacher staff development activities through its 10 campus-based centers. And the state's highly touted Governor's School of Science and Math uses its topnotch faculty to help teachers and students throughout the state.

Other good news:

- State task force recommendations in Colorado influenced a large percentage of local school districts to develop articulated math and science curricula. The three-year-old Colorado Alliance for Science links private sector resources with classrooms and finds summer jobs in industry for math and science teachers. The Alliance also is helping remote, rural schools, especially a group of 10 school districts in the San Luis Valley, develop a center to provide laboratory experiment programs, and telecommunication links are being explored to improve math and science instruction in isolated areas.

- With some of its federal grant money from the math and science improvement program, Ohio asked the Columbus schools to develop a two-year basic math program for the non-college-bound students, to be field-tested in the 1987-88 school year. Another federal grant program channeled to the Ohio Science Project is funding a study of revamping the science curriculum. It will produce a design for a sequential curriculum that also integrates all of the various sciences, grade by grade. Kathy Foster described one innovative local program in the Springfield city schools--where elementary and junior high school students no longer use "The Book," but, rather, use "The Box," a hands-on program that will give students a chance to perform up to 800 experiments by the time they finish eighth grade.

- North Carolina's activities center on a new science curriculum, spelling out what students should master at each grade level from kindergarten through high school. Also, four years ago all 100 counties received state funds for a math/science/computer coordinator to work with teachers on upgrading their skills. The state also funds summer employment on research and curriculum development for outstanding science and math teachers and provides scholarships on a competitive basis for science and math teachers to take further college work. A satellite television network is being planned to bring advanced courses to rural schools.

To come back around to the theme of control, it would seem that North Carolina's efforts to improve math and science instruction are more pervasive and organized than either those of Ohio and Colorado. The legislature, state department of public instruction and higher education system have worked together, through a combination of legislative mandates and organizational initiatives. It should be added, however, that many of the efforts began during the governorship of Jim Hunt, known as an "education governor" and former chairman of the Education Commission of the States, who has remained active with national education groups. While the other states did not have governors indifferent to education, they also did not have one with as strong leadership in this area, either.

In Ohio and Colorado, most of the science and math efforts concentrate on what the public perceives is the larger problem--the performance of secondary students. Elementary schools are just beginning to be viewed as important to the improvement of math and science skills. And curriculum development, while progressing in some areas, may not have as much an impact where it is provided as a guide, not a mandate, and does not tie into testing programs, as in North Carolina.

Another factor may be at work. Test results in Colorado indicate students there are doing well, compared to national averages (except for minority students). And state officials in Ohio admit the performance of their students is about middle, not something to brag about but also not alarming.

If the public believes there should be greater understanding of science and math by all students, it isn't evident yet.

SWEEPING CHANGES BYPASS COLORADO

James G. Wright, *Rocky Mountain News*

Danny Johnson is on the cutting edge of American school reform, but he'll never know it.

Danny has never shown much interest in class at suburban Dunstan Junior High in Lakewood, a middle-class suburb of Denver. Most days he sits in the back row of the eighth-grade class, doodling or goofing around, ignoring the teacher at the front of the room.

But something unusual happened to Danny last fall. He finished a homework assignment, his first in two years.

No one was more shocked and pleased than Bruce Hogue, the science teacher who gave Danny an A on the assignment.

"Last year his major accomplishment was setting a chair on fire," Hogue said of the student, whose real name is not important here.

"The assignment was to do a report, any kind of report, about brown cloud (Denver's air pollution problem)," Hogue explained. "This kid wrote a song about it and sang it on a rock video. It was the first homework assignment he's completed in two years. I got to him."

Hogue's science course has been cited as one of the best in the nation by the National Science Teachers Association. The group has twice honored suburban Denver's Jefferson County School District, which includes Dunstan Junior High.

Flexibility and non-traditional teaching methods are the key to the success of the applied science program, Hogue said. The course is intended for students who show little inclination toward science but operates on the premise that everyone needs to know scientific principles.

"Math and science instruction used to be lock-step, sit in your seat and keep your mouth shut," Hogue said. "(Now) we don't focus on science and then tack on the application, we go straight to the application and use just enough science to make it understandable."

Hogue uses a blend of science facts and social issues to get his point across. In tackling brown cloud, students see a laboratory demonstration that duplicates the condition and are told the scientific causes of air pollution. The lesson doesn't stop there. Once they understand the problem, students are asked to come up with solutions that are drafted into legislation.

That effort to relate the abstract math and science theories to real-life situations is a major part of Colorado's response to *A Nation At Risk*, the 1983 report of the National Commission on Excellence in Education.

The commission report focused critical attention on the failings of American schools, warning in near-lurid language that a "rising tide of mediocrity" in public education would soon engulf the nation.

Jefferson County's applied science program predates the national interest in education reform but has caught the attention of a nation looking for ways to stem the tide. At least once each week, an educator looking for fresh ideas visits Hogue's classroom.

"The big infusion we're going to see in the next 10 years is how science and technology affect society. Science is no longer for the scientists, it's for citizens who vote," said Dan Van Gorp, who coordinates another award-winning applied

science program in southeast Denver's Cherry Creek School District.

As in every state in the nation, Colorado has gone through its version of the search for education quality. In 1984, a task force organized by Gov. Richard D. Lamm found "pockets of excellence" in education but set a lofty goal for state schools.

"Our goal is large: system of excellence in education -- a system which will challenge each student to achieve to the fullest of that student's ability," the commission wrote.

It is difficult to say if Colorado is meeting that challenge. Unlike Texas or Tennessee, where radical overhaul of education has been attempted, Colorado has no unified educational system. Virtually all authority over some 39,000 teachers and 550,000 students is left to 177 local school boards.

Colorado, said Chris Pipho, director of the Information Clearinghouse of the Denver-based Education Commission of the States, is "the epitome of a local control state" where state officials are "not in the position to come around and inspect how the schools are doing."

The small state Department of Education is constitutionally barred from mandating graduation requirements, curriculum and textbook selection. It has formed a task force for each subject area but reports of those groups are only advisory.

In this diverse education system, the state has attempted few "top-down" education reforms, concentrating instead on minor efforts such as lengthening the school year by four days, requesting -- but not mandating -- more stringent high school graduation requirements and testing students to find soft spots in coursework.

As in Hogue's work with Danny, Colorado education reform has been a series of small victories won in individual schools and classrooms rather than sweeping changes.

"I just don't see any massive attempts to develop new materials or programs as much as to examine implementation of goals we already have," said Manert Kennedy, a University of Colorado education professor and executive director of the Colorado Alliance for Science, the state's largest math and science professional association.

A recent state Department of Education opinion survey showed that most Colorado teachers would agree with Kennedy. Of the teachers surveyed, 58% said they feel no effect on their work from reforms while another 21% feel "a negative impact." Only 19% said education reform had a positive effect.

While acknowledging that school districts are making individual advancement, Kennedy said there has been no measurable improvement in the quality of math and science education in Colorado.

"What we've seen so far I would put in the context of a crisis response," Kennedy said. "It's good that people perceive a problem, but what we need now is a broad plan of attack."

The slow pace of education reform in Colorado is both lauded and criticized by educators who say the state is dragging its feet on key issues that require money to fix.

"It (Colorado) is still a state where education reform is still a promise," said Bruce Goldberg, president of the Colorado Federation of Teachers. "But the bloom is off the rose, and you can't go around forever saying we'll live on our potential."

Others say the deliberate pace of reform has prevented a headlong rush into ill-conceived ideas.

Colorado Commissioner of Education Calvin Frazier says progress has been slow but the state is making good advancement considering the diffuse education system.

"In terms of actual number of reforms, the U.S. Department of Education ranks us something like 48th out of 50 states," Frazier said. "We probably have more grass-roots involvement than most states, but there's no mandated law that leads to a check in the box (on the federal questionnaire)."

Frazier said he's comfortable with local-level reforms but said it is impossible to tell if local changes have actually improved education.

"If I were to look down and ask if it (reform) really changed things and raised the level of math and science in our state, I'm not really sure I could say it has," Frazier said. "But I don't know that you could go to a district that can't show you something they're proud of -- a change they've made in t' : past two or three years because of a national report."

Frazier can offer an opinion but little hard information. Under the state's strict local control system, school districts are required to report little back to the state. Education Department surveys and data collected for federal grant applications do show that local schools are responding to the school reform movement.

More than two-thirds of the school districts have raised high school graduation requirements since 1983, with the majority now requiring at least two years of math and science for graduation. On average, districts now require 2.3 years of math and 2.1 years of science.

Educators are voluntarily following the recommendations of state task forces in improvement of math and science. A spring 1986 survey of 102 districts showed virtually all had drafted some curriculum improvement plan, and about 75% had used math and science task force reports as a guide.

The concept of articulating courses to provide a better progression of learning is also being adopted. Of the 102 districts surveyed, 83% have an articulated math program and 74% have an articulated science curriculum.

Individual teachers also are showing interest in new ideas. A recent seminar sponsored by the Colorado Council of Teachers of Mathematics attracted more than 700 teachers. The same program had an attendance of about 100 in 1983.

Schools and private industry are also working together to improve math and science instructions.

Kennedy's three-year-old Alliance for Science sponsors a visiting scientist program that puts 150 private sector engineers, scientists and researchers in the classroom as part-time teachers. It also provides summer jobs in industry for a dozen math and science teachers interested in honing their skills in the "real world."

And technology is coming to Colorado, especially in small, rural school districts that cannot afford extensive math and science education programs.

One program, Project Link, will someday bring state-of-the-art, computerized laboratory experiment programs to 10 school districts in the remote San Luis Valley, a high mountain valley so poor that Peace Corps volunteers train there before going overseas.

None of the schools in the valley can afford adequate laboratory equipment, so the program, to be sponsored by the Alliance for Science, would set up a resource center for the districts to share books and lab equipment.

A state satellite system to beam video tapes of math and science lectures to rural schools is also being studied by several education groups.

While promising initiatives, these efforts have not yet proven themselves. College-bound students who took the 1985 SAT test -- 17% of all high school graduates -- reported an average of 3.8 years of high school math, 1.4 years of biology and 2.1 years of physical science -- virtually the same as in 1983, before most high schools increased graduation standards.

SAT and ACT test scores of high school seniors remain among the highest in the nation in all categories but have not significantly changed over the past decade. About half of all Colorado high school students take one or both tests.

Individual school districts that have administered competency testing programs over the past four or more years report no significant change in math and science performance. California Achievement Test scores of freshman college students who plan to seek teacher certification have not changed since 1983.

Even areas specifically addressed by the Lamm commission have seen little change. The commission called for immediate action to reduce the student-teacher ratio, which in 1984 averaged 18.9 to 1. The ratio is now 18.4 to 1 and officials in major school districts say classes still range as high as 30 to 1.

As with so many things, money is the heart of the issue. With the bust of the oil boom, Colorado's economy has gone flat. Education, which receives more than 60% of the state budget, has had to take its share of cuts as tax revenues have declined.

"If anything, since 1981 science in Colorado has lost money," said John Peper, superintendent of the Jefferson County School District, the state's largest with 76,000 students.

"The problem is school district budgeting," Peper said. "We're losing money for supplies and materials because the state has made (2 percent) budget rescissions each year for the past four years."

Ron Wine, deputy director of the Colorado Association of School Boards, said finance remains the next great challenge for reform-minded educators.

"All of the reform in Colorado has been undertaken with relatively no new money," Wine said. "If anything, there's been a shift of funds away from math and science because districts have put more money into foreign language."

In assessing statewide reform efforts, Colorado math and science educators are critical of the increase in high school course requirements, which they said put quantity ahead of quality.

"If you've got mediocre science teaching and you double it, you've probably just made it worse," said Kennedy.

Others fear that requiring students with little interest in math and science to take additional courses will boost dropout rates.

"The good kids will take all the math and science courses available, regardless of the requirement. We've simply taken the average students and placed added

pressure on them," said C. Phil Gore, executive director of the Department of Education's East-Central Board of Cooperative Educational Services, which provides education support services for 15 small school districts in eastern Colorado.

Most Colorado educators feel their schools need some attention to quality issues but that a major, systematic overhaul is unnecessary. For support, they cite the results of the first-ever statewide achievement test administered last spring.

Results of the test, which was taken by all third, sixth, ninth and eleventh-grade students, show that Colorado students as a whole place well above average in all subjects, including math and science, but revealed disturbingly low scores for minority students.

White students scored significantly higher than Blacks, Hispanics, Native Americans and Asian-Americans in all subject areas and at all grade levels.

Test scores of Black and White 11th-graders showed the greatest disparity. Blacks scored in the 31st percentile in math and 37th percentile in science, compared with scores in the 63rd percentile in math and 69th percentile in science for white students.

Only Asian-American students posted test scores that were above the 50th percentile, or national average. Department of Education officials have been unable to give a definitive answer for the wide performance gap.

Several Colorado school districts and private groups sponsor programs aimed at improving math and science education for minorities, including the Mathematics, Engineering, Science Achievement (MESA) program sponsored by the Colorado Minority Engineering Association.

Started in 1979, MESA is a college-preparatory course for minority students from grades 7 to 12. About 1,200 students receive tutoring, special field trips and other help through the organization.

In separating test scores by residence, the Department of Education found that students from rural, agricultural school districts posted better math and science scores at the primary grades but fell behind students from urban and suburban junior high and high schools.

And while girls scored better on the standardized tests than did racial minorities, they were found less likely to take math and science courses.

A Department of Education survey of 1,000 students attending 19 large high schools shows that boys dominate science and math courses, even though the male-female ratio in Colorado schools is exactly even.

The survey shows that girls account for 38% of all physics and calculus students and 47% of the students in chemistry and basic-level computer science.

Advanced courses remain a male domain, however. Males represent 72% of all students in advanced computer courses. Little is being done to improve the participation of female students, although a few small seminars have been held to discuss equal access issues.

The testing program is the centerpiece of the state's Educational Quality Act of 1985, which took $4 million from state appropriations for local schools to finance the testing program and 123 research pilot projects.

Experimental programs financed under the act range from a dozen different

variations on career ladders to studies of managerial styles of principals. Only one project, which offered incentive pay for math teachers in one high school, dealt directly with math or science improvement, and that project was abandoned after just one year.

The research phase of the program will end in July and its completion may spark another wave of interest in education reform. The Department of Education will present its findings, along with proposed reform legislation, to state lawmakers in early 1988.

Many of those lawmakers will vote for modest changes, but major change is unlikely, largely because the diagnostic test showed relatively high marks for most students.

"In Colorado, we started with relatively good schools, did a few things to change things, but major issues which could have sweeping consequences have not taken place, nor will they," said Sen. Al Meiklejohn, chairman of the Senate Education Committee. "We just aren't as bad off as other states."

The perception that schools are adequate is common among community leaders and elected officials, who were recently surveyed by the Department of Education. More than 80% of those surveyed gave public schools a grade of B or better, with none assigning a failing grade.

Most education leaders say the most far-reaching reforms are being made not in public schools but in college and university classrooms where teachers are trained.

"Look at any good program and you'll find a good teacher behind it," Van Gorp said. "You can pour all kinds of money into it and re-write all the curriculum but if you don't have a good teacher behind it, you don't have a good science program."

In addition to the 1985 public school quality act, Colorado lawmakers ordered a radical change in the state's 14 colleges and universities that have teacher training programs -- they banned the undergraduate education major.

Starting next year, no state college will offer the elementary education degree. Instead, teacher certification candidates must have a broad liberal arts background.

Education degrees were ordered out in hopes that future teachers would be better versed in academic areas and spend less time in education methodology classes that are often perceived as less intellectually demanding.

In addition to phasing out the degrees, the state has ordered several small, regional colleges to drop their graduate education programs and has designated the University of Northern Colorado, which produces one-third of the state's certified teachers, as the state's primary teacher education institution.

Even at UNC, students in teacher certification programs will be limited in the number of education classes they can take. The state Commission on Higher Education will allow students to spend no more than 35 percent of their time in pedagogy classes.

A Nation at Risk found that, on average, education students spent 41 percent of their time in education classes, which is too high, it declared.

Teacher candidates will also face higher standards for admission to education classes. For the first time ever, the state will require that teacher candidates pass the California Achievement Test,

maintain a minimum college grade point average of 2.5 and spend 100 hours as a classroom observer before entering the program.

The new entry-level requirements are designed to weed out poor students and to expose candidates to real-life school problems early enough in their college careers to allow them to change majors if they don't like what they see.

Mathematics preparation is also getting more attention in education schools. The state recently instituted a requirement that all teacher candidates have at least two years of college preparatory mathematics before admission.

Once accepted for teacher training programs, students will face a 400-hour student teaching requirement, triple the practical experience requirement previously set by many schools.

Charles Branch, dean of professional programs at Denver's Metropolitan State College, said the message to education programs was clear and has been received.

"Those teacher education programs that have refused to listen and have been insensitive to the changes in public schools are listening now," Branch said. "They have no choice. They're being told to shape up or they'll be closed down."

Part of the shaping-up process has been re-establishment of links between college education programs and local schools. At all state colleges and universities, education professors are showing a new willingness to leave the ivory tower to help out in public schools.

According to the most recent Department of Education study, college professors staged special in-service training programs for 425 teachers in math, 1,271 in science and 1,742 in computer science during the 1984-85 school year.

"Their credibility has taken a beating because they haven't been out in the public schools," Philip Distefano, dean of the University of Colorado at Boulder's School of Education, said of education faculty members who are doing increased training and research in schools. "They're taking it upon themselves to do it as part of their assignment."

Accountability for the quality of graduates has also become an important factor at Colorado State University in Fort Collins. CSU, along with a local school district and the business community, has hired a researcher who monitors the work of CSU students teaching in Fort Collins-area schools. Inadequacies found by the researcher are reported back to the university for fine-tuning of education programs.

"The best way for us to be accountable with a university is to have that direct linkage with the schools," said Duane Jansen, CSU director of education.

For some colleges, direct linkage means an exchange of forces.

In Denver, Metropolitan State College and the University of Colorado at Denver send 20 recent graduates to teach under supervision in the Jefferson County School District. In return, Jefferson County loans the college and university 10 master teachers who both monitor the students and teach regular education classes.

At the University of Colorado at Boulder, an influx of older students entering teaching as a second career has prompted a revolution in teacher preparation courses.

The program, called Problem-Based Education (PROBE), stresses practical experience over traditional classroom lectures that older, more experienced students find boring, Distefano said.

PROBE students spend four to five hours each day in student teaching, double the state requirement. While currently limited to a small group of older students, the program will be open to most undergraduates in 1988.

A similar program, aimed specifically at older students who seek certification as math and science teachers, has been started at the University of Northern Colorado.

Many Rural Math Teachers Unqualified

Hundreds of Colorado public school students are learning math and science from teachers who are not qualified to teach them, according to a Colorado Department of Education survey.

The survey, completed in May for a federal grant application, revealed widespread employment of math and science teachers who have little or no formal training in those subjects, with most working in small, rural schools on Colorado's sparsely populated eastern plains.

The use of unqualified teachers in rural schools is so common that the Colorado Commission on Higher Education has declared upgrading skills of rural teachers the most pressing need in allocating federal funds for teacher training programs.

"We found particularly critical problems in math and science education in rural areas," said Charles Manning, deputy director of the commission. "We found teachers with only one collegiate course in their field in more cases than you care to think about."

Colorado teachers are required to take at least 20 semester hours of college-level courses in their general subject area and at least one course specifically related to each class they teach. For a high school physics teacher, for example, that means 20 hours of general college science courses and at least one class in physics.

While the majority of Colorado teachers meet the standard, the survey of 11,000 teachers in 102 school districts revealed a vast disparity in preparation between teachers in large urban and suburban school districts and those in small, rural schools.

Well-trained high school math teachers are in short supply in the state's 41 school districts that have fewer than 600 students. In those districts, less than half the math teachers meet the minimum educational requirement. Statewide, 81 percent of all math teachers meet the minimum.

High school science teachers reported slightly better preparation. About 60 percent of the rural districts met the state standard, compared with 82 percent statewide.

Most of the teachers reported taking only one to three collegiate math or science courses, and a few said they had avoided those subjects entirely. In those 41 small districts, 4 percent of the high school teachers and 1.8 percent of the junior high teachers had never taken a college math course.

In science, 1.4 percent of the high school and 5.3 percent of junior high teachers had avoided college science.

More than 69 percent of the rural high school computer science teachers failed to meet state standards, only slightly higher than the statewide rate of 66 percent.

In junior high schools, where the state does not require specialized college preparation, the statewide average of unqualified math and science teachers is 45 percent and 42 percent, respectively.

The qualifications of classroom teachers have only recently come under scrutiny in Colorado, where virtually all authority over education is by constitution left with the local school board.

Colorado's Department of Education does certify teachers, however, and is cracking down on violation of its regulations. Last spring, Department of Education officials audited certification files of teachers in one-fourth of the state's school districts and found that 21 percent of the districts had at least one instance where a staff member was teaching without a valid certificate. Another 47 percent had at least one high school teacher who was unqualified to teach in their subject area.

Those statistics confirmed in hard numbers what most Colorado educators had known for years.

Richard Hodge, math and science coordinator for the Greeley School District and member of the state's science education task force, said it is typical for small districts to hire a teacher qualified to teach biology and then add chemistry and physics to the workload "because he's the only one around."

"In some cases, a young teacher may be two pages ahead of the kids in the textbook," Hodge said. "Even if the teacher is intelligent and interested, lack of background in the subject can hurt his effectiveness."

Last summer, the Colorado Commission on Higher Education and the University of Northern Colorado at Greeley staged a special camp to upgrade the training of rural math and science teachers.

Jay Hackett, UNC coordinator of science education methods, said the level of preparation of those teachers was "shocking."

"We picked 20 (teachers) for the science program and the best quality teacher in there had no more than two (college) courses, total," Hackett said.

Even with unqualified teachers in the classroom, Colorado may be better off than many states. The bust of the petroleum industry has sent hundreds of former engineers and geologists back to school, with many of them taking teacher certification and joining the pool of available math and science teachers.

While 19 percent of all Colorado high school math and science teachers are unqualified to teach their courses, a 1981 study in North Carolina found 37.3 percent of math teachers and 30.4 percent of science teachers similarly unprepared, according to a 1986 American Federation of Teachers report titled "Making Do in the Classroom: A Report on the Misassignment of Teachers."

A 1983 study of Utah teachers showed nearly 76 percent of general science teachers, 82 percent of earth-science teachers, 43.1 percent of natural science teachers, 25 percent of biology teachers and 28 percent of math teachers had neither a college major or minor in their field.

In Colorado, money appears to be the major obstacle to attracting qualified teachers.

"It's getting harder and harder to get quality people (into teaching). We offer $15,000 starting against $44,000 in industry and the choice is easy for most people," said John Putnam, director of the Colorado Association of Teachers of Mathematics.

In many rural districts, starting teachers are paid as little as $12,000 per year while the average Colorado teacher is relatively well-paid, with some earning as much as $42,400 per year while the average teacher makes $26,000, $750 above the national average.

Money isn't everything, though. Small school districts located in Colorado's ski country have a much easier time attracting well-prepared teachers with equally low salaries. The lure of world-class skiing and resort living seems to make the difference.

But even districts that can find qualified teachers must spread that talent thin.

James Poole, superintendent of the tiny Bethune School District in far-eastern Colorado, just laughed when recently told that a governor's task force on education reform had recommended that teachers teach only four classes each day to provide more preparation time.

"I'm sure it would be ideal," said Poole, who has two teachers who each cover 7 separate math and science courses each day.

Bethune, with 100 students districtwide, recently lost its only science teacher. Poole was forced to split science courses between the district math teacher and physical education teacher. The math teacher is qualified, the PE teacher is not.

Colorado, like most states, has a surplus of teachers (44,268 qualified teachers for 29,000 jobs) but a shortage of math and science teachers.

State education officials estimate that the number of available math teachers is 19 percent short of current need, and the shortage will grow to 37 percent, or 1,032 teachers, by the year 2000. The supply of science teachers is adequate until the year 2000, when a shortage of 4 percent, or 976 teachers, is predicted.

Most of the shortage will be felt in elementary schools, where curriculum improvements include more attention to math and science. At the junior high and high school level, the state will actually have a surplus of math and science teachers.

The biggest need will be in computer science education, where the state will produce no new teachers for 600 elementary-level jobs and only 88 secondary teachers for 117 jobs.

College and university officials say they can't meet the demand but see growing numbers of students entering programs leading to teacher certification in math and science education.

At the University of Northern Colorado, the state's primary teacher education institution, the number of students intending to teach math and science have each doubled over the past four years, said Norma Nutter, dean of the College of Education.

Science teacher-candidates have increased by 46 percent over the same period, Nutter said. While large percentage increases, those figures reflect a small number of teachers -- from 30 math teachers in 1982 to 60 this year.

Other institutions report similar increases, which are attributed to a soft job market in engineering and business fields coupled with awareness of high demand for qualified teachers.

MATH AND SCIENCE IN SAD STATE; OHIO FIGHTS BACK

Kathy Gray Foster, *Columbus Dispatch*

Math and science education in the United States is in a shambles, one national report after another has declared in recent years.

Young Americans are scientifically and mathematically illiterate, say top educators.

Japanese, German, even children in the Soviet Union, are years ahead of average American children in math and science skills, education researchers warn. American children start trailing Japanese children in math understanding in kindergarten, one recent study concluded.

Math and science education has been hacked into little pieces in recent years, attacked from all sides as being boring, poorly taught and difficult to understand.

Ohio hasn't escaped the criticism. Educators here say that although Ohio's math and science education isn't among the nation's worst, it isn't a shining example of the best and the brightest.

"Ohio is only average to a little above average," said Robert Howe, director of the Education Resources Information Center (ERIC) on Math, Science and Environmental Education located in Columbus.

Since Ohio has no statewide testing, it is difficult to measure whether its students have gotten worse, better, or stayed the same in math and science over the last 10 years. But many educators say their math and science expertise has been slipping along with the rest of the country.

Nationwide, math scores on the American College Test slipped from 1970 to 1986, dropping from 19.1 to 17.3. Ohio's test scores fell during that time from 20.5 to 17.9. Science scores, both in Ohio and nationwide, stayed about the same.

But those scores only measure college-bound students, and only juniors and seniors in high school.

To find out how students as a whole were doing, the Ohio Department of Education gave math and science tests to a sampling of students across the state in the late 1970s.

Math tests given to about 3,000 fourth-graders revealed that while the students did well on basic math problems, they did poorly on problems that required reasoning to answer. The students, from a variety of backgrounds and schools, scored in the 90 percentiles on addition, for example, but scored 39 percent when they had to reason out answers.

In similar math tests given to a sampling of eighth-graders, students did well in problems involving whole numbers, personal finances and fractions. They did poorly in geometry and problems involving probability, measurements and ratios.

Science tests given to 12th-graders showed the students answered an average of only 61 percent of the questions correctly.

"The only indicators we have are the college board scores and those assessments we did in the late 1970s," said G. Robert Bowers, assistant state school superintendent. "But if you look at the international comparisons, clearly the United States does not measure up. And there's no reason to believe that Ohio is any different from the national norm."

But the torrent of criticism has brought

ripples of change to Ohio's math and science education.

Beginning with the graduating class of 1988, all high school students must have two years of mathematics instead of the one year now required to get an Ohio high school diploma. They still only need one year of science, however, one-third the amount needed in the 10 states that require three years.

Ohio universities have been prodding students to take more classes in high school math and science by limiting their admittance to universities if they lack certain classes.

Beginning in the early 1980s, students at state-assisted universities were admitted on an unconditional basis only if they had taken a certain number of high school courses. At Ohio State University, that includes three years of mathematics and two of natural science.

Students without that background still are admitted to the universities but may have to take remedial courses or begin their studies at a branch campus or at a different time than the popular autumn quarter.

Ohio also has been attacking the math-science problem by beefing up teacher education.

Students entering teacher preparation programs after July 1 must have 30 semester hours in math or science instead of the current 20 to get a math or science teaching certificate. To get a comprehensive science teaching certificate, which allows an individual to teach a variety of sciences to seventh- through 12th-graders, students will have to have 60 hours in science and 20 hours in each of the sciences they want to teach. Currently, students only need about eight hours in physics, for example to teach physics.

That change may not be as significant as it sounds, however. Bowers said the change may not affect the majority of students being prepared because many colleges and universities already require many more hours than the state minimums for their teacher candidates. But he predicted that the increase in minimum standards would prompt those schools to increase their requirements even further.

"It's the minimum that drives the norm," he said.

Bowers believes a change in regulations that was effective in 1980 may have more of an effect on how math and science as well as other subjects are taught. Beginning that year, teacher candidates had to have significantly more experience in actual classrooms to become certified to teach.

"I've seen very few teachers fail for want of subject matter knowledge," said Bowers. "Many more fail because they don't know how to deal with kids."

Ohio also has channeled about $560,000 in federal money to special math and science projects, including programs for minorities and females, lengthy brochures suggesting how to improve math instruction, and the Science Olympiad. The Olympiad is a science competition held annually for third- through 12th-graders. The national competition will be held in Ohio for the first time in 1987 and is expected to draw much attention to Ohio's science education.

But the largest chunk of federal money, $250,000 in 1986, is working to correct what Bowers sees as a major flaw in math curriculum across the state.

"Math curriculum has been a hodge-podge for the non-college bound," said Bowers.

High school students who don't plan to go to college need classes available that teach them two years of basic math that includes some algebra and geometry and emphasizes problem-solving. Although many high schools have one-year basic math classes, the textbooks and other materials don't exist for a good second-year program that follows up on the first year, Bowers said.

So the education department has asked Columbus schools to develop a two-year basic math program.

One of the primary aims is to develop classes that pique student interest.

"A lot of the general math being taught now is just taking care of the remediation that some kids need," said James Huber, Columbus math supervisor.

"We're trying to get away from that approach with this curriculum we're developing. These classes will be for kids who don't need remediation. We want to address the kids who already are prepared for high school mathematics. Hopefully, these classes will turn some students around so they'll want to take more advanced math classes, like algebra and geometry."

Huber and several Columbus teachers have been writing what amounts to textbooks for the courses. They will field-test the materials next year at several local high schools. They expect to get more federal money to pay for the second year of the study in the 1987-88 school year.

Huber wants to make math down-to-earth for students, so they learn how to use it in their daily lives and become interested enough to take more math.

Students would spend the first year learning to problem solve, a skill educators said is grossly neglected in most math classes. They would use math they've already learned to solve problems by collecting and analyzing data and writing equations.

The second year new materials would be added, such as statistics, numerical trigonometry and algebra, but in a more elementary way than in a college preparatory math class.

"We'll be trying to prepare them for post-high school education they'll receive, but not necessarily a college education," said Huber. "It's important to keep these students mathematically active with a course that has some meat to it."

Ohio educators have an even more extensive plan for science curriculum.

Researchers working on the Ohio Science Project are trying to develop a different framework for teaching science in all the elementary and secondary grades. The first year of the project was paid for with $151,000 in federal money channeled through the state in the 1986-87 school year. The funding for its second and last year is undetermined.

"Right now, science curriculum in Ohio doesn't have a developmental approach, meaning it doesn't start with certain concepts and build on those each year," said Howe of the Educational Resources Information Center. "We don't reuse what we've learned each year, and some stuff never gets covered."

Howe and John Schaff, a science professor at the University of Toledo, are directing the Ohio Science Project, trying to come up with a plan of what Ohio students should learn in science grade by grade.

Ideally, Howe said, science wouldn't be chopped up so that biology is taught one year, physics another year and earth science another year. All the various sciences would be integrated together, so that a little of all those sciences might be taught each year.

"It should be arranged so that it would go from familiar to abstract things for young kids, then from concrete reasoning ability to abstract reasoning," Howe said. "You would always be building on a background of familiarity."

First- and second-graders, for example, would examine leaves, learn to categorize them and watch how the wind affects them. Older elementary school students would study why leaves react in certain ways and how water and light affect plants. Further up the line, students would study the cells of a tree and how they work.

Although under state law the education department can't mandate a science curriculum for students as some states do, Howe hopes local districts will seriously consider the design produced by the project.

"One of the big problems is that there's too much reliance on textbook materials that don't stress the broader objectives of science," Howe said. "A lot of districts don't emphasize the thinking skills, the large concepts, and rational thinking skills."

Problems Start at Elementary Schools

Improving math and science education in Ohio is elementary, many educators say.

"I think the place to address this problem is at the elementary level," said Robert Howe, director of the ERIC Center located in Columbus.

"If we're trying to build a good foundation, we need to start in the elementary grades. Part of the problem is that kids get the attitude that those courses are hard. But if we can get kids to be successful in those subjects earlier, they might not have that attitude."

U.S. Secretary of Education William J. Bennett recently called for a "revolution" in elementary school science.

"Seen only as a laundry list of theorems in a workbook, science can be a bore," he wrote in *First Lessons*, a widely-distributed booklet expressing his views on U.S. education. "But as a "hands-on" adventure guided by a knowledgeable teacher, it can sweep children up in the excitement of discovery."

Ohio seems to have done little to improve elementary math and science teaching. The Ohio Department of Education sponsors some training workshops for teachers and produces booklets suggesting ways to improve math and science learning.

But they have not increased requirements for the amount of math and science background teachers must have.

Many elementary teachers have very limited backgrounds since they're required only to take a few semester hours of math and science to get their teaching certificates.

Howe said the average Ohio elementary teacher has taken only two to three college science courses. Once those teachers graduate, most take no more science classes; the statewide average is

0.1 to 0.2 hours of science training after college graduation for elementary school teachers.

Recent changes in teacher certification requirements haven't changed preparation in math and science.

Often, teachers don't spend a lot of time on the subjects because they're uncomfortable teaching them, Howe said. Or they can't find the time to fit them in once they cover reading, writing, spelling and other basics.

The same problems exist nationwide, according to a number of studies.

A study by Bowling Green University professor Leigh Chiarelott last year examined science education in the third through ninth grades in the Perrysburg school district in northern Ohio.

Chiarelott found that of the 19 elementary teachers questioned, 4 percent felt their preparation for teaching science was non-existent, 13 percent thought it was minimal and 42 percent though it was adequate. Only two teachers thought their preparation was "very good" and none thought it was "extensive."

Howe hopes a project he's working on to produce a model science curriculum will make a positive impact on the way science is taught in elementary schools. He hopes many districts will adopt the curriculum or parts of it.

In the meantime, he suggests elementary teachers reduce pencil and paper computations and increase the use of hand-held calculators so they have more time for math education. And he proposes that science lessons be integrated into other experiences, such as writing and reading, to expand science knowledge.

Luring Females and Minorities into Math and Science

Being male isn't a requirement for being a scientist or a mathematician.

But plenty of people still think that's true. So they pass that belief on to females, often unconsciously, in subtle and not-so-subtle ways, practically from the time females are born.

They buy their daughters Barbie dolls and tea sets and play ovens, while they shower their sons with erector sets and trains and chemistry sets. Before too many years have passed, the girls get the message: math and science are for boys.

That's the battle that schools in Ohio and across the nation are fighting as they try to encourage more females to take higher-level math and science courses.

"A lot of the problem is just historical, because it seems there's always been the myth that girls are better at verbal skills and boys are better at math and science," said Irene Bandy, assistant state school superintendent.

Although nationwide the math and science performance of girls is equal to boys in early grades, girls' average achievement test scores decline in the higher grades while boys' scores go up, according to the Ohio Department of Education's Office of Sex Equity.

The difference is dramatic even among males and females heading to college. While 40 percent of college-bound males have three or more years of high school mathematics, only 28 percent of college-bound females have that amount of math background, studies have shown.

And nationwide, average math scores on the Scholastic Achievement Test are generally 50 points higher for boys than girls. In Ohio in 1985, for example, boys averaged 527 points while girls only had 480 points on the SAT.

Those statistics have stayed steady in recent years, in both math and science. On the American College Test, math scores in 1975 were 19.7 for men and 16.6 for women, while science scores were 22.5 for men and 20.4 for women. The numbers were nearly the same in 1985, with math 19.4 for men and 16.7 for women and science 23.2 for men and 20.9 for women.

The problem also exists for minorities. In 1982, blacks nationwide scored 117 points lower than whites on the math portion of the SAT. In Ohio, statistics are similar, with blacks in 1985 averaging 403 points on the math portion of the SAT, while whites averaged 512 points.

At the same time, the U.S. Department of Labor predicts that 50 percent of the new jobs in upcoming years will require mathematics.

So the bottom line is that the lack of math and science expertise among females and minorities means many members of those groups will be excluded from science, math and technologically-related careers unless something changes.

Unless that disadvantage is removed, the unfavorable position of these groups in the workplace will get worse, the Office of Sex Equity concludes.

For the past four years, the Department of Education has been attacking the problem through training workshops for teachers, counselors and administrators, by sending out information about inequities in math and science, and through its support of private groups working on the problem.

At the workshops, participants are taught to notice subtle biases in textbooks, such as pictures of white, male engineers and scientists. They're given suggestions of how to overcome those biases by using posters or other additional materials that show minorities and females in those roles.

They're also taught to recognize their own biases and are shown ways to encourage minorities and females to pursue more math and science.

"We're trying to get girls as turned on to computers as boys are," said Bandy. "I think there's been a growing awareness of the problem which has helped."

To further that awareness, the department has distributed brochures about math, science and computer inequity to Ohio educators.

"Once again, the schools are becoming a breeding ground for a pattern of opportunity based on sex, race and class rather than on ability," they conclude.

They point out that boys outnumber girls by nearly two-to-one in computer science courses and that 80 percent of the high school students training for "low-paying, dead-end high tech jobs" are girls. And they give ideas of filmstrips, exercises and curriculum teachers can use to encourage females and minorities to increase their math and science education.

The department also has worked with Equals, a privately-funded organization in

Cleveland that promotes equality in math and science education throughout Ohio. The group, started originally in California with federal funds several years ago, opened a training center in Ohio two years ago.

Its main work has been training teachers and counselors on how to encourage more females and minorities to take math and science courses.

Bandy's biggest concern with math and science inequity, however, isn't for teachers. She believes the change must come at home, where attitudes about math and science are shaped.

"We have to help parents understand that it's just as important for little girls to have chemistry sets and microscopes as it is for little boys," said Bandy. "The most important thing is building an attitude that all children need exposure to math and science."

The department has published and distributed to local school districts a booklet showing parents how they can help both boys and girls develop skills and positive views about math and science. And they've encouraged school districts to talk with parents about the importance of upper level math and science courses for females and minorities.

Future Predictions

More students but not a dramatically higher number will take upper level high school math and science courses in the late 1980s and the 1990s, a top Ohio educator says.

"I think we've rounded the corner of the 1960s and 1970s, when enrollment dropped," said G. Robert Bowers, assistant Ohio school superintendent. "The percentage won't change greatly, but it will increase over time."

The main reason is simple, Bowers believes.

"Students didn't take those courses when they weren't required by colleges and universities," he said. "With colleges indicating that it's more or less a requirement now, that's enough of a prod."

The increased numbers in math and science classes will mean higher achievement levels in those subjects, Bowers predicts. Math scores also will get a boost from Ohio's new competency-based education, which requires districts to test students in reading, writing and math three times in elementary and secondary school. Educators hope the tests will improve student achievement in those three subjects by showing teachers what students don't know so that they can be retaught.

Certainly, as it looks now, achievement levels won't go up because more money is being spent to promote or improve the two subjects.

Special state and federal funding to redesign math and science classes or retrain math and science teachers is "very limited compared to the need," Bowers said, amounting only to a few million dollars a year in Ohio.

"When you go to appropriate that across the state, it doesn't go very far," he said. "I don't see any big push for more money."

In fact, the education budget submitted to the Ohio General Assembly by Ohio Governor Richard F. Celeste eliminates one program, "Excellence Funds," aimed at improving math, science and written composition education.

Districts have been able to get grants from that $1 million fund for continuing education workshops for teachers. It is the only state money directly set aside to improve math and science education.

It is unclear if legislators will attempt to put that back into the budget.

Robert Howe, Director of the ERIC Center, is hopeful about the future of math and science education in Ohio.

"I'm more optimistic at this time, because the state is trying to do some things," he said. "The last two years, there have been some improvements."

But one big problem remains. Nearly half of Ohio high schools are small. 346 have less than 500 students and 147 have less than 300. That means they often can't afford or have the necessary number of students to offer advanced math and science courses on a yearly basis.

"Sometimes those schools will have only one science teacher, while in larger high schools you'll have several," said Bowers.

That means small-town science teachers have to be experts in all the sciences, while teachers at larger schools are more specialists.

The Department of Education could not provide information on how many high schools offer higher level math and science courses.

"The challenge facing us now is to make these higher level courses available to students in smaller high schools," he said. State educators are considering experimenting with classes taught on television or perhaps interactive video-discs.

That might become even more necessary if small districts can't attract math and science teachers as Bowers expects.

Getting math and science teachers to take assignments in small schools is difficult because they have to teach such a variety of classes and those districts often don't pay as well as larger systems, he said.

Bowers also predicts Ohio may further strengthen its high school graduation requirements by adding a semester of computer science and two years of science instead of one. He expects the state also will require teachers to take a computer course to become certified within a few years.

No Teacher Shortage in Ohio

"Teacher shortage, teacher shortage" newspaper headlines threaten as educators nationwide predict a dangerous deficit looming in the classroom.

Math and science teachers are particular targets of this gloom and doom scenario.

And indeed, it apparently is true in some parts of the country. As a result, some districts are allowing teachers without proper training to teach and some are importing teachers from other countries.

But not Ohio, says G. Robert Bowers, assistant state school superintendent.

"There's no question there's a teacher shortage in certain geographical areas and in certain subjects, but there isn't one here," Bowers said.

Although the pool of newly-graduating teachers has dropped sharply the last few years in subjects like math and science, there still are enough to go around, he said.

In part, that's because Ohio's enrollment has been dropping since its peak of 2.4 million students in 1972. By the beginning of the 1986-87 school year, it had plummeted to just below 1.8 million (about the same as in 1960), and Bowers predicts it will fall to 1.6 million by 1995.

By studying the number of graduating teachers in each field and the number who actually go into teaching just out of school, Bowers has determined that Ohio colleges and universities need to produce about twice as many graduates as there are openings for brand new teachers each year. That's because many graduating teachers don't go into teaching.

In 1987, for example, he predicts 244 math teachers will graduate and there will be a need for 145 of those in Ohio classrooms.

Although that doesn't quite meet the 2-to-1 ratio, Bowers predicts it is close enough so there won't be shortages. That 145 represents about 45 percent of the total openings in Ohio for math teachers; the remaining 55 percent would be filled by teachers reentering the field after one or more years of not teaching.

In future years, the numbers would be similar. In 1988, the supply would be 267 and the demand 143; in 1889, 293 and 141; in 1990, 293 and 139.

There is one hitch.

The percentage of newly-graduating teachers needed is growing each year. In 1984, it was 30 percent; by 1986, it had crept up 14 points to 44 percent.

But Bowers expects the percentage of those teachers needed each year to begin leveling off in the next few years, so a shortage won't materialize.

Ohio is trying to short circuit any potential shortage with a teacher loan program it started last year. Under the program, students studying to become math, science and foreign language teachers can receive up to $5,000 a year for tuition.

Twenty percent of the loan is forgiven for every year the individual teaches that subject in an Ohio school. An additional five percent is forgiven for every year the borrower teaches in a district identified as a potential shortage location.

The program also offers up to $15,000 in consolidation loans to students who graduate each spring and plan to teach shortage subjects. The same rules apply under that program as for students in the loan-forgiveness program.

Last year, the state gave out $500,000 in loans to 145 students. In 1987, it has $1 million to distribute.

One thing Ohio isn't doing, at least not to a great degree, is allowing people without proper training to teach.

Last year, about 3 percent of Ohio's teachers, or about 2,400, were teaching without proper certification or on temporary certificates. The state has no

breakdown of what percentage of these teachers are math or science teachers. But Bowers said more are in math and science than in other subjects.

About one percent of the misassigned teachers last year were on temporary certificates, which the department issues for one year. Teachers can renew those certificates for another year if they take six hours of college classes in that subject.

Teachers can only get temporary certificates if the superintendent of their school district asks for the certificate on the grounds that a shortage of teachers in that subject exists in their district.

The other 2 percent of the misassigned teachers were discovered by the department's on-site checks of schools, which it makes at least every five years.

Despite the department's downplaying of the problem, it is concerned enough to make initial plans to cross-check teachers in the future with the classes they're teaching via computers. Bowers describes the process as "a nightmare" but hopes it will become a reality in the near future.

Spicing Up Mathematics

"Manipulatives" is the latest buzzword in math education.

They're nothing new. Actually, they may be as old as history itself.

But their rebirth is one thing that may help revolutionize math education.

A manipulative is any physical object a student uses to understand math. It could be as simple as marbles that first graders line up on their desks to help with addition problems.

What it does is make math more concrete because students can visualize what they're learning, explained G. Robert Bowers, assistant state school superintendent.

The point is, said Steve Meiring, a math specialist at the Ohio Department of Education, that students can see that when they add two marbles to two marbles that they have four marbles. They don't have to visualize the addition in their heads.

It's akin to counting on your fingers.

Teachers and parents have used manipulatives for years to help preschoolers and young children learn the basics of math.

But those hands-on tools usually aren't used in upper grades for math, said Meiring.

"Manipulatives appear to be at a rudimentary level almost like they're only for low-level math skills but there's nothing wrong with a child learning to count on their fingers," he said. "For one thing, they get the one-to-one connection that their finger stands for one unit."

"Kids have to visualize ideas, to have pictorial models, because that's how we begin to build so we can understand bigger problems. Even in high schools, we don't lose the need to see things spatially."

Some teachers always have used manipulatives, although they may not have called them that. But Meiring hopes to train others, including elementary

teachers, to make manipulatives part of their math classes.

He demonstrates manipulatives in workshops for teachers and math supervisors and has developed materials about them he can send to teachers.

Meiring doesn't suggest that manipulatives should replace textbooks. He believes the two can work hand-in-hand.

But he also urges teachers to dramatize the texts, especially in younger grades.

If a teacher needs to know how much chocolate and white milk to get from the cafeteria for the whole class, for example, he can have the children who want chocolate milk stand on one side of the room and those who want white milk stand on the other side. Then the students can count each group.

"What you have to recognize is that kids through the second grade use a lot of intuitive skills and need a lot of acting out," he said.

That example points out that hands-on learning doesn't translate into big bucks. Although there are plenty of manipulatives that can be purchased, many can easily be made by teachers or students themselves.

"And the equipment you need you can get at a gravel pit," said Bowers. "Although there are lots of fancy manipulatives, most of them can be replicated with ordinary things."

Even in science classrooms, where hands-on experiences have been common for years, Ohio educators are clamoring for more active student involvement in learning. Although science teachers have long known the value of letting students pick apart a worm's innards, they've been stymied by the high cost of worms, less money for worms and less student teacher experience with worms.

Robert Howe, Director of the ERIC Center, said studies have shown that 1983 was the peak year for the lack of hands-on science teaching.

"Teachers used a lot more of it in the early 1970s than they use now," he said. "And now, because student teachers see it less, they don't learn how to do it."

To change that, the Ohio education department puts on an annual three-day conference where science teachers can practice experiments and other hands-on learning. The department also co-sponsors Project Wild, workshops where teachers learn environmental education in a hands-on style.

Each of the 50 Project Wild participants each year is asked to train 60 teachers, so that the teaching methods spread throughout the state.

Innovative Science Program Offers Promise in Springfield

Textbooks have been banned in Springfield City Schools' elementary and junior high science classes.

Last year, the 12,000-student district became the first in the state to begin a completely hands-on science curriculum for kindergarten through eighth-graders. No textbooks are used, either as supplements or as daily guides.

Instead of The Book, students learn from The Box, a container filled with

directions and all the paraphernalia the class will need to learn science. Each teacher gets one of the boxes, specially prepared for the class he teaches, from the district's science supervisor every few months.

So instead of reading about the human skeleton in the sixth grade, students take apart an owl pellet, a mass of bones and other body parts owls regurgitate after they swallow an animal whole. The sixth-graders sort through the pellet and reassemble the animal skeleton, learning the names of the bones as they go along and comparing them with a human skeleton.

John Bartley, Springfield science supervisor, estimates students will do 650 to 800 experiments by the time they finish eighth grade under the new curriculum. Nearly everything they do is an experiment, from sorting piles of seashells of similar shape or color as kindergarteners to observing and recording which wild birds eat which type of birdseed as first graders.

Under the textbook curriculum, students usually did only a handful of experiments during those nine years.

Bartley started the hands-on program because he found science instruction sorely lacking in elementary classes.

"Science was generally taught on Friday afternoons, if they didn't have an assembly or fire drill," he said.

Most elementary teachers felt uncomfortable teaching it, so little was taught.

Now, students in lower elementary grades spend 90 minutes a week on science, students in upper elementary grades spend 120 minutes a week and seventh and eighth graders spend 200 minutes a week.

The new program is being phased in, three grade levels at a time. The final three grades, second, third and fourth, will be added in the 1987-1988 school year.

Teachers get two 40-hour weeks of training before they begin using hands-on science in their classrooms. The National Science Foundation is picking up the $240,000 tab for the training, which is done at Wittenberg University.

Although the program hasn't been operating long enough to quantify its results, the enthusiastic response of students and teachers has convinced Bartley the change is for the better.

Last year, he found that 90 percent of the fifth graders taking hands-on science said they would stay after school to take it if that was the only time it was offered.

"Something right is happening when I walk down the hall and two girls are talking about their mystery circuit boards rather than boys and Bruce Springsteen," he said.

Although the up-front costs for hands-on science are much greater than a textbook curriculum, costs are lower after that because textbooks have to be purchased every five years.

Bartley figures hands-on science costs $15 a student the first year, then $3 a student every year after that for supplies. Under the old curriculum, textbooks, purchased every five years, cost $11 to $16, and workbooks, purchased annually, cost $2.50 per student.

"Outside of the personnel costs, over the long haul it's no more expensive than textbook courses," he said. "And the greater involvement of the kids makes up for any extra costs."

Bartley said about 20 other school districts nationwide have similar hands-on science programs; one in Illinois has been operating about 15 years.

But while more than 30 Ohio school districts already have visited Bartley's program, none has yet copied it completely.

"Sometimes I think the cost scares them off, or the logistics of sending the materials to each teacher every few months," he said. "And it takes 60-hour work weeks to crank the thing out."

But Bartley's school board, facing staff layoffs and a huge deficit, has so much confidence in the program that they recently voted him enough money to continue it the next three years.

Although Springfield developed its hands-on science program on its own, innovative programs often develop with the help of local businesses. Businessmen hope investing in youngsters' math and science skills will mean more knowledgeable employees in the future.

While there has been no statewide push to involve businesses with schools, many local districts have enlisted the help of businesses to expand their math and science education. Urban districts have a leg up on rural districts in this area, since most of the business are in cities.

Battelle Memorial Institute Foundation, for example, gave Columbus Public Schools about $250,000 in 1982 to start the Battelle Youth Science Program. Each year since then, about 50 high school juniors and seniors have had half a day daily of advanced science and math classes under the program.

In Cleveland, the Museum of Natural History and the Martha Holden Jennings Foundation joined forces to sponsor a week of workshops for math and science teachers, geared at teaching them techniques to help children become better problem-solvers.

Cleveland schools also are involved in a National Science Foundation project aimed at developing a hands-on science program for urban elementary students. Cleveland is one of six school systems collaborating on the project using a $2.1 million grant from the foundation and $1.9 million from Delta Education, Inc., a New Hampshire publishing company.

SCIENCE AND MATH IN NORTH CAROLINA'S SCHOOLS: THE INCOMPLETE REVOLUTION

David S. Perkins, *The News and Observer*

Currituck County, a rural school system on two spits of land joined by a ferry ride at the northern end of the Outer Banks, is a good mirror of the state's half-complete revolution in science and math education since 1980.

With its 2,000 students, single high school, and small tax base, Currituck generally sees change after the rest of the state. In 1980, Currituck's science and math teaching had a simplicity that smacked of the frontier age. The high school did not offer a calculus class. Its physics class had only four students.

In the elementary schools, supplies were so inadequate that teachers paid for batteries or prisms out of their own pockets, if they were innovative enough to try experiments. The curriculum was the approved textbook, which teachers were free to skip and often did, according to school officials.

Consider the changes in less than a decade. In the school year just ending, the calculus class, first offered in 1982, had five pupils. The physics course had eight and, next fall, will rise to 15.

In 1983, Currituck's teachers developed a new elementary-grade curriculum binding math and science skills that won a Governor's award. New microscopes, prisms, computers, flasks and other equipment for elementary science have been purchased with state funds.

"Five years ago, we tended to have the kids read a section (in the textbook) and answer questions," said Jane Cross, the system's curriculum supervisor. "Now we're much more likely to use the book as a reference and use the materials."

"Five years ago," she added, "we couldn't have put a prism in the hand of every child in the system."

In North Carolina, an enormous effort has been made in science and math education since 1983 affecting curriculum, testing, and equipment.

But the hardest stretch could lie ahead. Low enrollments in teacher education programs and intense competition for graduates from industry are making it harder for local school systems to find adequately trained teachers. Attrition continues. As a result, underprepared teachers are being assigned to teach classes that would otherwise go teacherless.

The problems don't stop there. Many teachers, particularly in the middle school and elementary grades, say their training is inadequate for the advanced concepts they're being asked to teach. "How do we use computers, not for drills, but for math instruction?" they're asking. "Just what do we do with this shiny new science equipment?" And, "How can we use hands-on experiments to teach the new state curriculum?"

"The demands are there, but we're struggling to get the quality staff that we need to meet those demands," said William C. Church, a special assistant for secondary education. First, however, the improvements.

State Action in Math and Science Since 1983

Curriculum

A new statewide science curriculum was approved in 1985 that required science in grades K-8 to cover earth, life and physical science. As a result, 7th and 8th grade science, formerly split into life and earth science, was integrated to give students a more unified curriculum before specializing in high school.

The science curriculum was then folded into the new state Standard Course of Study - a 1985 guide for local systems devising their own curricula - that spells out the concepts and skills students should master at each grade level and in each subject from kindergarten to high school.

"It encourages teachers to go by a planned program, rather than jumping from here to there in the textbook," said Paul H. Taylor, director of the Division of Science in the state Department of Public Instruction.

Staff and Staff Development

In 1983, all 100 counties received state funds for one math-science-computer programming coordinator to work with teachers on curriculum and in-service programs.

In addition, the N.C. General Assembly provided funds to extend the employment for 700 math and science teachers statewide in an effort to retain some of the better math and science teachers. These teachers work six weeks in the summer, doing research, developing the curriculum or teaching summer school.

Also since 1983, the state has paid 100 science and math teachers a year, on a competitive basis, $1,000 scholarships to take at least six hours of college credit during the summer.

Through the University of North Carolina's Math-Science Network, which started in 1984 to merge college-level expertise and in-service needs, 8,000 middle and high school teachers have taken workshops or for-credit courses at centers at 10 UNC campuses.

Middle school teachers, thousands of whom were teaching with elementary grade certificates in the early 1980s, have been the centers' main users. After a statewide controversy in 1984 about the number of teachers "out-of-field," state certification rules were changed and hundreds of middle school teachers were forced to take additional college course-work. Many network workshops have been geared to the new integrated science curriculum for grades 7-8.

As a result of the network's activity and the new certification rules, out-of-field assignments have declined, although there are worrisome signs that the trend may be reversing. According to the state Department of Public Instruction, in 1981-82, 30 percent of the state's 3,595 science teachers in grades 7-12 were not certified in any science. In 1985-86, that had declined to 7 percent.

Equipment

Before 1985, local school boards were on their own when it came to buying science equipment and supplies, and the poorer districts, naturally, fared worst. In 1984-85, Currituck's board budgeted $600 for science equipment in grades K-6.

In 1985, however, the legislature appropriated $5.4 million for science and

math equipment and materials. The appropriations were renewed in the same amounts in 1985-86 and 1986-87.

Tests

Mandatory state tests in science began in spring 1985 for grades 3, 6, and 9, geared to the state's science curriculum. The tests are putting pressure on teachers to follow the assigned curriculum and are giving the public a measure of student progress.

Requirements

Enrollment in science and math classes is significantly up statewide as a result of high school graduation requirements that went into effect for this summer's graduating class and the approach of higher UNC system entrance requirements next year.

The state still requires two units of math and two of science -- the science curriculum study recommended going to three -- but the State Board of Education in 1985 required local units to add two required units of their choice, bringing the total from 18 to 20 units for graduation. Many systems -- including Wake County -- have required more math and science.

In addition, the UNC system will require its fall 1988 applicants to show three years of science and three years of math on their transcripts. Previously, the 16 UNC campuses set their own admissions requirements, and few required as much science or math as the new rules call for. UNC-Chapel Hill, the state's capstone campus, requires only two years of science for admission.

The impact of the requirements is already being felt. Science enrollment in grades 7-12 increased from 349,467 students in 1981-82, to 364,367 in 1985-86. The increase is actually larger than it appears because total student enrollment (average daily membership) dropped by about 2,000 students.

Statewide, units of physics increased from 379 with 7,037 students in 1981-82 to 433 with 8,589 students in 1985-86, according to the state department. Advanced or second-year physics increased from 10 classes, with 119 students, to 15 classes, with 234 students. Calculus classes increased from 122 (2,087 students) to 206 (3,431 students).

"It's a turnaround," says Joseph E. Webb, assistant state superintendent for instructional services. "We're backing away from offering everything in the world in high school, and high school students are no longer frowning upon academic excellence."

A Qualified Teaching Force - Possible at a Time Shortage?

Despite the curriculum changes, new tests and gleaming new equipment, North Carolina lacks the qualified teachers to carry the new load.

Spot shortages of science and math teachers are common in the state's mountain and coastal counties, which can't match the local salary supplements offered by urban or large systems. And the shortages are expected to become more acute and affect more counties in the years ahead.

In a January 1986 state survey, 23 of 129 school systems reported a critical

need for certified math teachers, while 22 said they had a critical need for science teachers.

Many school systems are responding to the shortage by hiring teachers trained in other fields under provisional state certificates. Brunswick County schools, for example, hired six additional high school math and science teachers in fall 1985 to meet a surging course enrollment. Several had minimal college coursework in science and were hired on provisional certificates.

"It means we're having to use some people whose area of expertise is not entirely in the area they're teaching," said Superintendent V.E. Yarbrough. "It could be a lot better, but it's probably as good as we can do at the moment."

North Carolina school systems are expected to have an even harder time in the next five to ten years filling the growing number of positions. A 1986 study of teacher supply-demand by the University of North Carolina predicted a "severe shortage" of math teachers and a less serious shortage of science teachers ahead unless education schools are suddenly flooded with students. According to the study, the state will need 1,902 more math-computer science teachers by 1990-91, 153 more chemistry teachers, 77 more physics teachers, and 649 more general science teachers than current output will produce.

The shortages would be much less acute but for the state's ambitious effort to hire thousands of additional teachers to reduce class size and teach the expanded statewide curriculum. The Basic Education Program approved by the legislature in 1985 proposes hiring 11,000 new teachers by 1992 to create a more equitable network of schools across the state. The BEP is coming up on the third year of an eight-year funding schedule.

"Lateral Entry" Has Not Yet Fulfilled Promise

The hope that good science and math teachers could be drawn from the private sector if the obstacle of a teaching certificate were removed so far has been unrealized.

A new "lateral entry" program was approved by the State Board of Education in 1985 that allows school systems to hire retirees or people from industry who lack teaching certificates. The idea came as a response to looming shortages as well as to skepticism about college-based teacher preparation.

But, in the program's first year, 1985-86, few of the 163 teachers hired under the plan were in math and science. Of those, 15 were hired in math, eight in comprehensive science, six in biology, four in chemistry and one in physics. The bulk were hired to teach in areas where teachers are abundant, such as English, counseling, and social studies.

"The incentives just aren't there yet in terms of pay" to draw scientists from the private sector, says Brock Murray, assistant director of the Division of Certification in the state department.

It is not possible to tell how many lateral entry teachers came from industry with high qualifications and how many were stop-gap hires. Deans of education are skeptical of the program, saying the current salary picture means high quality

people will not use this new side-door into teaching.

In some school systems, however, "lateral entry" has already made a difference. In Currituck, a former Florida-based oceanographer with a master's degree from the University of Florida teaches biology in the high school's four-member science department.

Schools of Education See Enrollment Rise

A more encouraging sign is coming from schools of education, where student enrollment is taking an upswing after 10 years of decline. At North Carolina State University in Raleigh, which produces about one-fourth of the state's high school math and science teachers, School of Education majors in science and math have risen for three years in a row after roughly a decade-long decline, and will take their biggest jump next fall. In fall 1985, 123 NCSU students were enrolled in math education (freshmen through seniors). The next year, there were 138, and next fall they are projected to increase to 170. In the sciences, the enrollment figures were 47, 68, and 85 -- a near-doubling in three years.

Other education schools in North Carolina are reporting similar surges as students respond to higher state salaries, reports of reform, and professional incentives in teaching through career ladders and merit pay plans.

In fact, math and science education majors pulled out of the general decline in teacher education enrollment several years ago. But the increase has been offset by the low percentage of math and science graduates who go into teaching. In 1980, the state department found that 30 percent of first-year secondary science teachers dropped out during or immediately after their first year of teaching. No study has been done to determine whether that percentage is improving or deteriorating.

Math education saw its surge begin in 1980. Graduates in that area at North Carolina colleges and universities increased almost 39 percent since 1980, according to UNC system figures. In 1980, institutions in the state awarded degrees to 107 math-computer graduates. In 1984-85, the figure was 149.

The specialized sciences -- physics, chemistry and biology -- have seen only a trickle of graduates, despite increased demand. Only two students have graduated in physics education since 1980-81. Biology graduates declined from 58 in 1981-82 to 37 in 1984-85, and chemistry graduates from 14 to 8.

Physics and chemistry majors are quickly hired by private industry at considerably higher salaries than teaching can offer, college deans say.

Predictably, school systems are responding by turning to provisional emergency certification to fill vacancies with teachers who often lack proper training.

The state department did not have figures immediately available on emergency certificates, but supporting evidence of a rise in out-of-field assignment is provided by the 1986 UNC Teacher Supply-Demand Study.

- In math/computer science, 20 percent of the 493 new hires in 1985-86 were assigned out-of-field, as compared

with 13 percent for the entire number of math/computer science teachers.

o In general science, 26 percent of new hires were out-of-field, as compared to 14.6 percent overall.

However, science certification is so loose at the secondary level that out-of-field is a term with little meaning. About a third of the state's science teachers -- and most of the physics and chemistry teachers -- hold comprehensive science certificates, a general category that allows teachers to teach any science in grades 9-12. For the certificate, students specialize in one science, and take a smaller number of courses in two other sciences.

Educators agree that these teachers are generally under-prepared in all of the subject areas, even the one of their concentration. But the broad certification is necessary, state officials say, as long as industry grabs students with more specialized training and because many North Carolina high schools also lack the course enrollments to justify hiring a full-time physics or chemistry teacher.

Teacher Education: Awaiting Changes

Shouldn't stronger teachers be the responsibility of teacher training schools? State education officials (echoing a 1982 state science curriculum study) say they'd like to see tougher requirements in training, but improvements are unlikely unless the state goes to a five-year preparation program, a direction that the UNC system rejected in 1986.

"We aren't satisfied with the level of teacher preparation," said Paul H. Taylor of the state department. "At the elementary level, they don't get enough science in college, and that's probably true of all levels, to teach effectively. They probably need another year of college training, but that's not reasonable to expect."

In response to recommendations by the 1985 UNC task force on teaching, the 15 UNC campuses that train teachers will require, beginning next fall, education students to major in a basic academic subject in addition to education. The UNC system's secondary math education program -- at N.C. State -- already requires similar levels of math as math department majors, so no big change is expected.

But whether the rule should apply to science education majors, who often are aiming for a general certification to teach biology, earth sciences, chemistry and physics, is still being debated. One option under review is to require science teachers to complete the major requirements in one science and a smaller number of courses in the other sciences.

A 1986 UNC edict that may have more of an impact calls for doing away with the generally low-level "Science For Teachers" or "Math for Teachers" courses that are taught in some education schools. Henceforth, science and math departments will be fully responsible for teaching teachers in those subjects.

Math-Science Network Bridges the Gap

Teachers have long complained that in-service workshops are relevant but weak, and academic coursework is strong but irrelevant to classroom needs.

The UNC system's Math-Science Network, funded with $1.6 annually from the General Assembly and Title II funds, appears to have started to bridge that gap, although there is some room to go. The network is addressing problems of math-science instruction and generating research relevant to teacher's needs. It has helped to give basic for-credit courses a practical spin and given academic minds the stimulus of finding ways to lay firmer foundations in math and science in the schools.

For example, UNC-Charlotte has developed a directory of role models for use in encouraging more blacks and women to take science and math in high school. N.C. State has developed packages of in-service materials for math teachers. In the North Carolina Governor's School of Science and Math's "Science as a Verb" workshop, teachers launch rockets, tracking them with altimeters, build kaleidoscopes, and discover how the bladder wort, an insect, can demonstrate elements of water pressure.

There does appear, nevertheless, to be some room for improvement. The 10 centers are only beginning to address a key area -- curriculum development. The UNC Chapel Hill center, for example, has worked with teachers from the Chapel Hill-Carrboro schools to develop a math curriculum using the Logo computer language.

There also seems to be little tie-in between the centers' coursework and the new state curriculum, and the Network remains a university -- rather than a school-based enterprise.

"If there's a piece of criticism I'd level at teacher education, it is that they tend to expect teachers to come to them, or to satellite sites," says Roy H. Forbes, former director of the Rural Education Institute at East Carolina University and now a private consultant. "If the university people are going to be talking about how you make use of the local environment in teaching science they should be able to go into local schools and actually teach the course."

The North Carolina Governor's School of Science and Math in Winston-Salem is showing how such interactive links could work. Under an initial Title II grant, a professor of physics at the school, Hugh Haskell, worked with physics teachers at four high schools in Lincoln and Warren counties, helping them to plan curricula and use equipment. He visited classrooms once a month and talked with teachers at least once a week by telephone.

The classrooms were outfitted with conference telephones, which students used to pepper Haskell with questions in once-a-month free-for-all sessions.

So far, the Math-Science Network has concentrated on middle school and high school teachers and not worked with elementary teachers. Next year, more workshops are planned for elementary teachers.

In addition, it is launching a series of pre-college programs in science and math to identify and offer enhanced instruction to minorities and women, two groups seriously underrepresented in advanced high school math and science classes. The Network hopes these programs will stimulate students to become science and math majors -- and eventually classroom teachers in those fields.

On the Horizon - Other Improvements

Linkages Between Colleges and Schools

Several North Carolina universities, including UNC-Charlotte, are starting six-year master's degree programs that include extended internships in the public schools and closer working relationships between college faculty and master teachers. The long time-span should allow more basic subject matter to be taught in the early years and more pedagogy to be learned on the job. And, it is hoped, more joint efforts will be made to find ways to teach the assigned curriculum in science and math.

Scholarships to Increase the Teaching Pool

Lt. Gov. Robert D. Jordan II has called the state's efforts to recruit more teachers by subsidizing their education the most ambitious undertaking of its kind in the country. The North Carolina Fellows Program, expected to be funded with $9.7 million for the first two years by the legislature this summer, would provide four-year scholarships worth $5,000 a year to 400 students, on a merit basis, beginning in the fall. In return for the scholarships, the students promise to teach in North Carolina schools, retiring one year of debt with one year of service. The response was immediate and overwhelming: 1,553 students applied for the first 400 scholarships.

A linked program of two-year scholarships for college juniors (50 scholarships of $4,000 a year) also will begin this fall specifically tied to counties and subjects where there are shortages. Priority is being given to applicants with an interest in science and math.

The Fellows program complements an older state scholarship fund that provides 200 $2,000 scholarships a year, renewable each year.

Meanwhile, Texas oil millionaire and North Carolina native Walter R. Davis this spring announced a $1.4 million scholarship fund at UNC-Chapel Hill specifically for prospective science and math teachers. In return for the scholarships, which will cover full tuition and expenses, the recipients would commit themselves to teaching five years in eastern North Carolina schools.

Stipends

An idea that could help rural school districts with shortages is to pay stipends to those teachers who volunteer to fill vacancies in science and math.

The UNC system's recent Task force on Teacher Education recommended stipends last fall, but the legislature has yet to take any action.

Team Teaching

School systems have used team teaching approaches in middle schools, with some teachers specializing in science and math. The Chapel Hill-Carrboro schools are beginning to experiment with team-teaching in elementary grades to draw on superior expertise of some teachers.

Technology and the Two North Carolina's

North Carolina, like other Southeastern states, is polarized between the poor, rural counties in the coastal east and the mountainous west, where small tax bases make for low local support and enrollments in advanced courses are likely to be small.

Many remote schools pin their hopes on a satellite television network that the state department is working on that would broadcast advanced classes around the state. Planning money already has been approved by the legislature.

APPENDIX A

Sweeping Changes Bypass Colorado

Jim Wright, *Rocky Mountain News*

News looks ahead, projects the final 64 on road to New Orleans

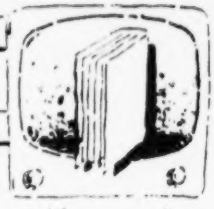
SPORTS/PAGES 6-C

TV DIAL

Fluff fills 'I'll Take Manhattan'/4

ENTERTAINMENT

Creators discuss mini-series/8-E



Rocky Mountain News

128th year, No. 313 DENVER, COLORADO SUNDAY MARCH 1, 1987 75 cents in Colorado

Schools bypass reforms

Colorado's system stagnant 3 years after study/7

JANET REEVES Rocky Mountain News

Chugwater fights for school

Chugwater, Wyo., whose school has an enrollment of only 103, has fought the district's attempts to close the school for almost 20 years. The battle is joined once again. Some students would face daily bus rides of 110 miles if the school is closed. STORY/32

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EDUCATION REFORM: A PROGRESS REPORT

Most teachers welcome a fresh approach

Continued from page 7

wide reform movement.

For example, the governor's commission recommended that high schools increase the number of English, math and science classes required for graduation, from one each in most schools to at least two.

Since the report, more than two-thirds of the school districts have done so. Most now require at least three years of English, 89% require two years of math and 84% require two years of science.

The schools also are taking lessons from a series of state task force reports on better ways to teach academic courses. A state report on math and science programs found all but a few of the 102 school districts surveyed had drafted a plan to improve course work, and two-thirds used the state report as a guide.

Also teaching the teachers are their former professors, who are studying education in the classroom and helping teachers improve their skills, said Philip Distefano, dean of the University of Colorado at Boulder school of education.

"We thought we could do everything, and the public schools thought they could do everything," Distefano said, "and now, we've begun to realize that, to be effective, we have to look at each of our strengths."

And teachers are embracing new ideas. A recent seminar sponsored by the Colorado Council of Teachers of Mathematics attracted more than 700 participants, compared with a turnout of about 100 in 1983.

But while individual schools adopt reforms, Colorado educators have little evidence that reform has improved school quality. In some cases, they argue, quality actually may suffer from reforms.

Boosting graduation requirements, for example, was a major theme in the "Nation at Risk" report, and most schools took it to heart.

Many educators now say it was a cosmetic change having little effect on the 40% of Colorado students who plan to go to college. Their course work is dictated by college admission standards, often twice as stringent as those for high school graduation, and the number of courses they take has not increased significantly since new standards went into effect.

Nor has their performance on standardized, college-admission tests changed. Colorado high school graduates post some of the highest average scores in the nation, but those scores have not changed much in the past decade.

Little is known about the effect of the increased requirements on the 60% of the state's high school graduates who do not attend college, but some educators say the change may actually harm their educational achievement.

"If you've got mediocre science teaching and you double it, you've probably just made it worse," said Manert Kennedy, a CU-Boulder education professor who heads the Alliance for Science.

In many instances, even areas the state has singled out as crisis points haven't been addressed.

The governor's commission, for example, called for immediate reduction in the teacher-student ratio, 18.9-1 on average in 1984. Today the ratio is only slightly lower — 18.4-1.

Proponents of more drastic change fault the state for taking a cautious approach rather than launching the immediate and sweeping fix seen in at least a dozen other states.

"The Department of Education says this is an advantage, that we've avoided some of the pitfalls (of rapid change), but you don't hear so often that those states (making major changes) poured hundreds of millions of dollars into changing their educational systems," said Goldberg. "They've built momentum to continue reform."

Others say Colorado schools don't need massive change.

A recent Department of Education survey of community leaders, the public and elected officials found that more than 80% of those surveyed gave Colorado public schools a grade of B or better. None gave a failing grade.

And Colorado lawmakers, who considered more than 100 education-reform bills in legislative sessions following the "Nation at Risk" report, decided against sweeping change.

"We started with relatively good schools, did a few things to change things, but major issues which could have sweeping consequences have not taken place — nor will they," said Sen. Al Meiklejohn, chairman of the Senate education committee. "We just aren't as bad off as other states."

Instead, the 1985 General Assembly launched a two-year program of competency tests, studies and experiments to reveal areas needing work. That study, the 2-plus-2 project, will be completed in July.

The project's early findings support Meiklejohn's assessment. With one glaring exception — minority youth — Colorado students scored well above average on the tests given as part of the 2-plus-2 project.

School leaders say financial issues are the next point of debate in efforts to improve education.

The 1987 General Assembly is considering several bills on school finance, all of which aim to shift the expense from local property taxpayers to a statewide funding base.

Meiklejohn has introduced legislation to boost state funding by an estimated $250 million, at least half of which would simply offset a simultaneous decrease in property taxes.

His proposal has little chance of passing because of the price, but less expensive proposals are being readied for consideration.

LIBRARY FILE/Rocky Mountain News

Calvin Frazier, Colorado commissioner of education, says most school districts point with pride to changes they've made in the past two or three years.

Rural districts can't afford qualified teachers

Continued from page 7

eration of Teachers report, "Making Do in the Classroom: A Report on the Misassignment of Teachers."

And a 1983 study in Utah found nearly 76% of general science teachers, 82% of earth-science teachers, 43.1% of natural science teachers, 25% of biology teachers and 28% of math teachers had not majored or minored in their field.

In Colorado's small districts, money appears to be the major obstacle to attracting qualified teachers.

"It's getting harder and harder to get quality people. We offer $15,000 starting, against $40,000 in industry, and the choice is easy for most people," said John Putnam, director of the Colorado Association of Teachers of Mathematics.

In many rural districts, starting teachers are paid as little as $13,000 per year. But the average Colorado teacher is relatively well-paid, earning $26,000 a year, $750 above the national average.

Money isn't everything. Small school districts in ski country more easily attract well prepared teachers with equally low salaries.

Still, even those districts that find qualified teachers must spread the talent thin.

James Poole, superintendent of the tiny Bethune School District in far-eastern Colorado, laughed when told a governor's task force on education reform had recommended teachers teach only four classes a day to leave time to prepare.

"I'm sure it would be ideal," said Poole. His two teachers each cover seven math and science courses each day.

Bethune, with 100 students, recently lost its only science teacher. Poole was forced to split the science courses between the math teacher, who is qualified to teach science, and the physical education teacher, who is not.

Colorado, like most states, has a surplus of teachers — 44,268 qualified teachers for 29,000 jobs — but a shortage of math teachers.

State education officials estimate that shortage at 19% and predict it will grow to 37% by the year 2000. The supply of science teachers is adequate until the year 2000, when a shortage of 4% is predicted.

Most of the shortage will be felt in elementary schools, where more emphasis is being placed on math and science. At the junior high and high school level, the state will actually have a surplus of math and science teachers.

College and university officials say they can't meet the demand but see growing numbers of students seeking certificates in math and science education. The collapse of the petroleum industry has sent hundreds of former engineers and geologists back to school, many of them acquiring certificates and joining the pool of available math and science teachers.

Oil bust may be boon to public schools

By JAMES G. WRIGHT
Rocky Mountain News Staff Writer

Some educators call it a silver lining in the dark cloud of falling oil prices: As jobs in the oil patch vanish, hundreds of former petroleum engineers and geologists are starting second careers as math and science teachers.

Take David Guilinger. The 29-year-old Greeley West High School science teacher was a mineral geologist working out of Denver until 1982, when he saw the shape of things to come.

"Business was drying up, and I needed to find something new," Guilinger said. Having worked as a teaching assistant while getting his master's degree, "this seemed like an easy switch to make."

After a year at the University of Northern Colorado to acquire a teaching certificate, Guilinger landed a job in Greeley, earning $15,000 less a year than he did as a full-time geologist. "It's enough to live on, but not exotically," said Guilinger, who supplements his income with summertime consulting work.

In 1983, Guilinger was the only petroleum refugee studying at UNC for a second career in the classroom. Today the program is packed with them.

Jay Hackett, director of the UNC earth-science education program, says he gets a call at least once each week from a geologist who wants information about returning to school.

At the University of Colorado-Denver, which specializes in graduate programs for second-career students, enrollment has grown from 338 students in 1982 to 2,542 this fall.

Some educators, while welcoming help in filling math and science jobs, fear that the former petroleum workers will be fair-weather teachers.

"I'm really excited about some of them. They're good, quality people with a strong work ethic," Hackett said. "But some of them are just looking for something to do, a stop-gap measure until the oil industry opens up again."

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EDUCATION REFORM: A PROGRESS REPORT

Sweeping changes bypass Colorado

By JAMES G. WRIGHT
Rocky Mountain News Staff Writer

Three years after a national task force declared American public schools a danger to the future of the republic, educators and teachers agree that Colorado schools remain largely untouched by education reform.

Despite dozens of state and national reports, studies and research projects, they say, Colorado's schools have made no sweeping changes in the way students learn.

"THIS IS a state where education reform is still a promise," said Bruce Goldberg, president of the 1,000-member Colorado Federation of Teachers.

Many teachers agree with Goldberg: A recent poll by the Colorado Department of Education found that 58% of the teachers surveyed said education reform has had no effect on their work, while another 21% said they feel "a negative impact."

Fewer than one in five saw a positive effect from education reforms in their schools.

Still, Colorado commissioner of education Calvin Frazier said subtle changes are taking place that might escape teachers' notice.

"If I were to look down and ask if it (reform) really changed things and raised the level (of education) in our state, I'm not really sure I could say it has," Frazier said. "But I don't know that you could go to a district that can't show you something (it's) proud of — a change they've made in the past two or three years because of a national report."

It is difficult to do anything in American education today without bumping into a report calling for public school reform.

THE LEADER of the pack was the 1983 "Nation at Risk" report of the presidential Commission on Excellence in Education. It warned that a "rising tide of mediocrity" was engulfing public education, with math and science courses needing the most help.

State legislatures responded with more studies and special sessions on education reform. Most set tough standards and ordered tests to check the quality of their schools. Some — notably Texas, Tennessee and North Carolina — pumped hundreds of millions of dollars into excellence programs.

In Colorado, former Gov. Richard D. Lamm formed a blue-ribbon panel to study school quality. The task force found "pockets of excellence" within the same sea of mediocrity and set a lofty standard:

"Our goal is large: A system of excellence in education — a system which will challenge each student to achieve to the fullest of that student's ability."

But Colorado officials since have done little to alter education in the state, other than to order a four-day longer school year.

"In terms of actual number of reforms, the U.S. Department of Education ranks us something like 48th out of 50 states," Frazier said, but "we probably have more grassroots involvement than most states."

UNDER THE state constitution, most authority over Colorado's 39,000 teachers and 550,000 students resides with 177 local school boards.

The Colorado Department of Education can recommend change and offer grants to entice it, but cannot order even the most common of school reforms, increased requirements for high school graduation and changes in coursework.

That doesn't mean the schools are floundering. Several statewide surveys and reform assessment programs show they are adopting some key principles of the nation-

See MOST TEACHERS, page 20

LINDA McCONNELL, Rocky Mountain News

Philip Distefano, dean of the University of Colorado school of education, says it's important that teacher-training institutions and public schools examine and understand the strengths of each.

Many rural math teachers unqualified

By JAMES G. WRIGHT
Rocky Mountain News Capitol Bureau

Hundreds of public school students in rural Colorado are learning math and science from teachers who are not qualified to teach those classes, according to a Colorado Department of Education survey.

The use of unqualified teachers, mostly in small schools on the sparsely populated eastern plains, is so common that the Colorado Commission on Higher Education has declared upgrading skills of rural teachers the most pressing need in allocating federal funds for teacher training.

"We found particularly critical problems in math and science education in rural areas," said Charles Manning, deputy director of the commission. "We found teachers with only one collegiate course in their field, in more cases than you care to think about."

The state survey was completed last May for a federal grant application but was not reported until now.

Colorado teachers must take at least 20 semester hours of college-level courses in their general subject area, and at least one course specifically related to each class they teach.

For a high school physics teacher, for example, that means 20 hours of general college science courses and at least one class in physics.

The majority of Colorado's 11,000 teachers in 102 school districts surveyed met the standards.

But in the 41 school districts with fewer than 600 students, less than half the math teachers met the minimum educational requirement, lowering the statewide level to 81% of all math teachers who met the minimum.

Among high school science teachers, about 60% of the rural teachers met the state standard. The statewide figure was 62%.

The biggest problem is in computer science. Statewide, 66% of computer science teachers in high schools failed to meet the standard. The rate among rural teachers was only slightly higher, 69%.

> "In some cases, a young teacher may be two pages ahead of the kids in the textbook."
>
> Richard Hodge, math-science coordinator, Greeley School District

In the junior high schools, where the state does not require specialized college preparation, 45% of the state's math teachers and 42% of the science teachers had not majored in the subjects they were teaching.

The qualifications of classroom teachers have only recently come under scrutiny in Colorado, where virtually all authority over education rests with the local school board. The May 1986 survey is believed to be the first of its kind.

While state officials can set minimum qualifications for teachers, their enforcement powers are limited. They cannot withhold money from districts that misassign teachers, for example.

Last spring, Department of Education officials audited the teaching certificates in a quarter of the state's school districts and found that 21% of the districts had at least one teacher without a valid certificate. Another 47% had at least one high school teacher unqualified to teach in the subject area.

The statistics confirm what most Colorado educators have known for years.

Richard Hodge, math and science coordinator for the Greeley School District and member of the state's science education task force, said small districts typically hire a teacher qualified to teach biology, then add chemistry and physics to the workload because he's the only one around.

"In some cases, a young teacher may be two pages ahead of the kids in the textbook," Hodge said. "Even if the teacher is intelligent and interested, lack of background in the subject can hurt his effectiveness."

Yet Colorado may be better off than many states.

A 1981 study in North Carolina found 37.3% of math teachers and 30.4% of science teachers unprepared to teach those subjects, according to a 1986 American Fed-

See RURAL DISTRICTS, page 20

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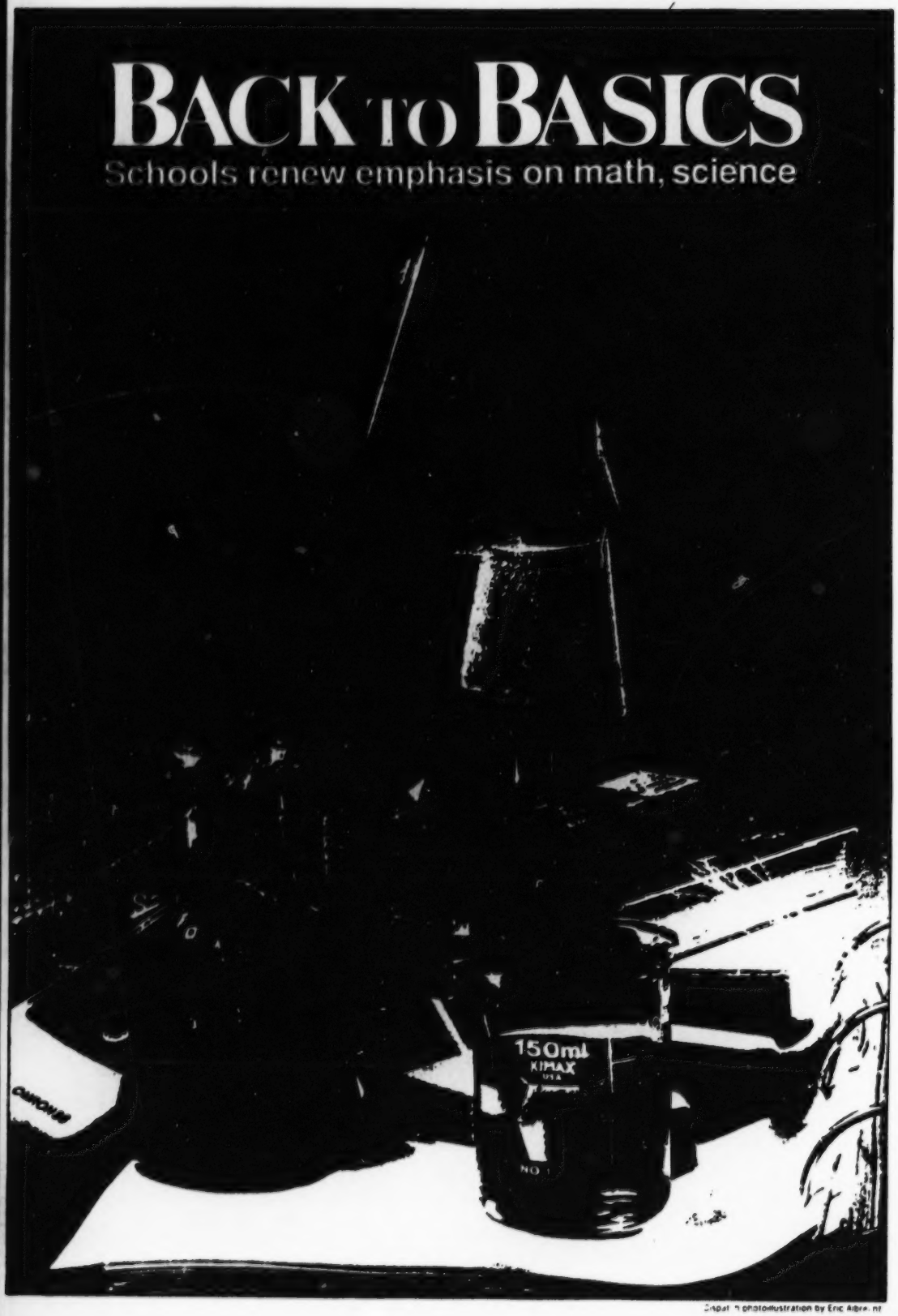
APPENDIX B

Math and Science in Sad State; Ohio Fights Back

Kathy Gray Foster, *Columbus Dispatch*

BACK TO BASICS

Schools renew emphasis on math, science



Dispatch photoillustration by Eric Albrecht

Can Johnny add? Can Jane?

In some cases, no. That's what education reporter Kathy Gray Foster concludes in this report on math and science education in Ohio schools.

In several months of investigation, Foster discovered a lack of science taught in elementary classrooms, educators who say many science teachers are unqualified and females who are subtly convinced from birth that math and science are male domains.

But she found bright spots, too, including innovative teachers who are trying to dust off the dull, boring image of math and science and bring the subjects alive for students.

The following stories offer a glimpse into the problems and provide some possible solutions to combat illiteracy in these critical subjects.

Stories by Kathy Gray Foster
Dispatch Science Reporter

Math and science education has been hacked into rattle pieces in recent years, attacked from all sides as being boring, poorly taught and difficult to understand. Young Americans are scientifically and mathematically illiterate, experts warn.

Japanese, German and even Russian children are years ahead of most American children in math and science, they say. In fact, American children fall behind Japanese children in math in kindergarten, a recent study concluded.

Ohio hasn't escaped the criticism. Although its math and science education isn't among the worst, neither is it a shining example of progress.

"OHIO IS only average to a little above average," said Robert Howe, director of the Education Resources Information Center.

Ohio has no statewide testing, so it is difficult to measure whether students have gotten better or worse or stayed the same in math and science in the last 10 years. But many educators say students here are sliding too.

"If you look at the international comparisons, clearly the United States does not measure up," said G. Robert Bowers, assistant state school superintendent. "And there's no reason to believe that Ohio is any different from the national norm."

One measure is the American College Test, taken by college-bound high school juniors and seniors.

Nationwide, average math scores on the test slipped by 9.4 percent from 1970 to 1986, dropping from 19.1 to 17.3.

Ohio test scores, while staying higher than national averages, fell slightly more. They dropped by 12.7 percent during that time, from 20.1 to 17.9.

ACT science scores, both in Ohio and nationwide, stayed about the same.

Another gauge — a state-administered math tests given to Ohio students in the late 1970s.

The sampling showed the 1986 fourth-graders did well on basic calculations but poorly on word problems requiring advanced reasoning skills. They scored in the 90 percentiles on simple addition, but only 19 percent figured out how much it costs three friends to share a $3.60 pizza equally.

Eighth-graders did well on problems involving whole numbers, personal finances and fractions but poorly on geometry, probabilities, measurements and ratios.

The torrent of criticism has brought ripples of change to Ohio's math and science education.

BEGINNING IN 1988, high school graduates must have two years of math instead of the one year now required. The requirement is the same in 30 other states, according to the Education Commission of the States. Ten states require three years and two require one year.

Ohio students still need only one year of science, but leaders predicted that eventually will be changed to two

Please see **BASICS** next page

BACK TO BASICS continued from 1 D

years. He also expects a semester of computer science to become a requirement.

Four states require one year of science; three states require three years and 35 states two years. Five states have no state requirements and two require five years total of math and science combined.

That would be welcome news to state-assisted Ohio universities. Since the early 1980s the colleges have been prodding students to sharpen their math and science skills by limiting college admission if students lack certain classes.

AT OHIO STATE University the requirement is three years of mathematics and two of natural science. Deficient applicants may have to take remedial courses or begin their studies at a branch campus or at a different time than the popular autumn quarter.

That change, Bowers said, is "enough of a prod" to prompt slightly higher enrollment in high school math and science classes and, as a result, higher achievement levels in those subjects.

Math proficiency will also be encouraged by Ohio's new requirement that districts test students for competency in reading, writing and math three times during elementary and secondary school. Educators hope the tests will alert teachers to what students don't know, so these areas can be re-taught.

Ohio is also stiffening teacher-training requirements.

Future teachers after July 1 must have 30 semester hours instead of 20 in math or science to get a math or science teaching certificate. To teach a variety of sciences in seventh through 12th grades, graduates will need 60 hours of science as well as 20 hours in the science subject they want to teach. Now, for example, students need only about eight hours in physics to teach physics.

Math proficiency level on SAT

Year	ACT* Ohio	ACT national	SAT** Ohio	SAT national
1971	20.5	19.1	497	487
1972	20.2	18.8	495	484
1973	20.1	19.1	496	481
1974	19.4	18.3	500	480
1975	18.5	17.6	499	472
1976	18.1	17.5	504	472
1977	18.2	17.4	506	470
1978	18.3	17.5	504	468
1979	18.2	17.5	502	467
1980	18.0	17.4	499	466
1981	18.2	17.3	500	466
1982	17.9	17.2	502	467
1983	17.7	16.9	504	468
1984	18.2	17.3	508	471
1985	17.9	17.2	504	475
1986	17.9	17.3	503	475

*American College Test
**Scholastic Aptitude Test

Dispatch graphic

care of the remediation that some kids need," said James Huber, Columbus math supervisor, who is heading the project.

"We're trying to get away from that approach with this curriculum. We want to address the kids who already are prepared for high school mathematics.

"Hopefully, these classes will turn some students around so they'll want to take more advanced math classes, like algebra and geometry."

Educators say today's typical math curriculum for students not going to college is a hodgepodge.

High school graduates going straight into the job market still need some algebra, geometry and a general math background. Although high schools have one-year basic math classes, most don't offer a second year. Textbooks and materials for such a program don't even exist.

The challenge in such a program is to pique student interest.

Huber and several teachers have been writing texts for the courses that will be tried out next year at several local high schools.

THE IDEA is to convince students that mathematics has practical uses in their daily lives.

During the first year, they would learn to solve problems, a skill educators say often is neglected in math. The second year they would take on new skills, such as statistics, numerical trigonometry and algebra, taught in a simpler way than in a college preparatory classes.

"We'll be trying to prepare them for post-high school education they'll receive, but not necessarily a college education," said Huber. "It's important to keep these students mathematically active with a course that has some meat to it."

Ohio educators also are working to restructure how science is taught.

An example is the $151,000 federally sponsored Ohio Science Project to design a new teaching framework for science in all grades.

"Right now, science curriculum in Ohio doesn't have a developmental approach, meaning it doesn't start with certain concepts and build on those each year," said Howe from the Educational Resources Information Center. "We don't reuse what we've learned each year, and some stuff never gets covered."

Howe and University of Toledo professor John Schaff want to develop a grade-by-grade map of what students should learn in science.

Ideally, Howe said, science wouldn't be chopped up so that biology is taught one year, physics another and earth sciences another. Subjects now separated would be integrated so that aspects of all those sciences would be taught each year.

"It should be arranged so that it would go from familiar to abstract things for young kids, then from concrete reasoning ability to abstract reasoning," Howe said. "You would always be building on a background of familiarity."

FIRST- AND second-graders, for example, would examine leaves, learn to categorize them and watch how the wind affects them.

Older elementary school students would study why leaves react in certain ways and how water and light affect plants. Further up the line, students would study the cells of a tree and how they work.

The state can't mandate a statewide science curriculum, but Howe hopes local districts consider the new design.

BOWERS EXPECTS a computer course will also be required for certification within a few years.

But the changes aren't as significant as they sound. Bowers said they won't affect most students because many colleges already require of their teacher candidates more than the state certification minimum. But he predicted that the increase in minimum standards will prompt schools to increase their requirements even more.

Bowers also points to 1980 changes in Ohio that significantly increased the amount of actual classroom experience each teacher candidate must have for certification.

"I've seen very few teachers fail for want of subject-matter knowledge," said Bowers. "Many more fail because they don't know how to deal with kids."

The state's priority seems to be changing the curriculum for students rather than teachers.

Ohio has channeled about $500,000 in federal money into special math and science projects, including programs for minorities and females, detailed booklets on how teachers can spice up their math classes, and the Science Olympiad.

OHIO HOSTS the Olympiad, an annual national science competition for third through 12th graders, for the first time this year. The competition is expected to generate much public interest in science education in Ohio and encourage more Ohio teachers to enter the contest.

The largest single effort is a $250,000 state contract to the Columbus schools to develop a two-year basic math program. It is funded with federal money.

"A lot of the general math being taught now is just taking

"One of the big problems is that there's too much reliance on textbook materials that don't stress the broader objectives of science," he said. "A lot of districts don't emphasize the thinking skills, the large concepts and rational thinking skills."

State funding of special programs to improve math and science is a sorrier picture, however. Educators' concerns haven't translated into a lot of extra money.

In fact, Ohio Gov. Richard F. Celeste's budget would eliminate the only state money directly set aside to improve math and science education.

Districts have been able to get grants from that $1 million fund, called Excellence Funds, for continuing education workshops for teachers. Its purpose is to improve education in math, science and written composition. It is unclear if legislators will attempt to put that back into the budget.

BEST COPY AVAILABLE

Teachers, like students, often shy away from science

The entire world is your textbook when you teach science.

But team-teaching with Mother Nature is an unsettling prospect to those elementary school teachers with little background in science.

"Teachers in general have the feeling that they have to be scientists to teach science," said Rosemary Pearson, who trains Columbus Public elementary teachers on science subjects.

"BUT I think we've taught them in workshops that you don't have to know all the answers to teach it. It's just the world around them that they're teaching about, and they find they know so much more than they think they know."

Pearson is a special resource teacher at Berwick Elementary School, the district's special math and science school.

Next fall, three similar Columbus elementary schools will be added, and all have been popular with parents signing up for the district's alternative schools.

But Pearson said elementary teachers at any school can learn to teach science in an interesting way by taking advantage of the natural curiosity of children.

Each class at Berwick this spring, for example, is planting a garden. One teacher has used the class plot as a math tool by having students step around it to better understand a perimeter.

"IF YOU CAN make it real, then it's going to stick," Pearson said.

Pearson is careful not to get too technical in her workshops.

"If you walk around a field and start identifying each individual tree, that just turns them off because they feel if they can't do that, they can't teach science," she said. "You don't have to know if it's a maple or an oak to do interesting things with it."

Many educators believe the effort to improve math and science education should begin in the lower grades.

"I think the place to address this problem is at the elementary level," said Robert Howe, director of the Educational Resources Information Center, a national clearinghouse for math, science and environmental studies information located at Ohio State University.

"If we're trying to build a good foundation, we need to start in the elementary grades. Part of the problem is that kids get the attitude that those courses are hard. But if we can get kids to be successful in those subjects earlier, they might not have that attitude."

U.S. SECRETARY of Education William J. Bennett recently called for a "revolution" in elementary school science.

"Seen only as a laundry list of theorems in a workbook, science can be a bore," he wrote in "First Lessons," a widely distributed booklet expressing his views on education. "But as a "hands-on" adventure guided by a knowledgeable teacher, it can sweep children up in the excitement of discovery."

A 1983 National Science Board report estimated that less than 2 percent of the nation's elementary children obtain a solid education in science.

Lynn Elfner, executive officer of the Ohio Academy of Science, believes the biggest problem with math and science education is unqualified teachers at the elementary and secondary levels.

"There's a huge number of people who only meet the minimum requirements set by the state, and those requirements allow rather minimally qualified people to teach science," Elfner said. "And the same is true of math."

He blames colleges and universities for failing to deal with the problem.

"MOST SCIENCE teachers lack the in-depth understanding of what they're teaching," he said. "They (colleges) are overloading them with methods courses. You should eliminate one-third of them and replace them with science courses."

Elfner believes the necessary changes will occur only when college presidents push for them, he said.

"Retraining teachers in workshops after they get out is just a Band-Aid approach," he said.

Many elementary teachers have limited math and science backgrounds, since they're required only to take a few semester hours on such subjects. These teachers avoid science in the classroom because they're uncomfortable with teaching it, said Elfner.

Bowling Green University professor Leigh Chiarelott last year talked with 25 teachers teaching grades three through nine in the Perrysburg school district in northern Ohio. Four percent believed their preparation for teaching science was non-existent, 13 percent thought it was minimal and 42 percent said it was adequate. The remainder thought their preparation was extensive or very good. Among the third- through sixth- grade teachers, only two thought their preparation was "very good." None in that group thought their preparation was "extensive."

Dispatch photo by Fred Squillante

Six-year-old Jessica Morton, left, and Carrie Chupick, 8, of Berwick Elementary tend to Bun Bun, the class rabbit.

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The Columbus Dispatch
SUNDAY, MAY 24, 1987
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BACK TO BASICS

BREAKING WITH TRADITION

Who says science is for boys?

Stories by Kathy Gray Foster
Dispatch Schools Reporter

Being male isn't a requirement for being a scientist or a mathematician.

But plenty of people still think that's true. So they pass that belief on to females, often unconsciously, in subtle and not-so-subtle ways from the day they are born.

They buy their daughters Barbie dolls and tea sets and play ovens, while they give their sons Erector sets and telescopes and chemistry sets. And before too many years have passed, girls get the message: Math and science are for boys.

THIS IS the mind-set that schools confront when they try to encourage females to take higher-level math and science courses.

"A lot of the problem is just historical, because it seems there's always been the myth that girls are better at verbal skills and boys are better at math and science," said Irene Bandy, assistant state school superintendent.

Although girls and boys perform equally well in early grades, the girls' scores on science and mathematics achievement decline on the average during high school while average scores for the boys go up, according to the Ohio Department of Education's Office of Sex Equity.

The difference is dramatic even among students going to college. While 40 percent of college-bound males have three or more years of high school mathematics, only 28 percent of college-bound females have that amount of math background, according to studies.

The experts think that's because females have been subtly convinced as they grow up that they don't need or don't have the aptitude for higher-level math and science.

Nationwide, average math scores on the Scholastic Achievement Test are usually about 50 points higher for boys than girls. In Ohio in 1985, for example, boys averaged 527 points while girls averaged 480 on the SAT.

THIS GENDER GAP isn't shrinking, despite the women's movement. In 1975, average math scores on the American College Test were 19.7 for men and 16.6 for women, while science scores were 22.5 for men and 20.4 for women. In 1985, the men averaged 19.4 on math and 23.2 on science, while the women averaged 16.7 on math and 20.9 on science.

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BREAKING WITH TRADITION

A sampling of last year's graduates in math and science departments at Ohio State University also tells the story.

The College of Math and Physical Sciences, which includes chemistry, math and physics majors, graduated 94 men and 34 women. The College of Biological Sciences, which includes botany, genetics and zoology, had 112 male and 95 female graduates. And the College of Engineering, which includes computer science and chemical and civil engineering majors, graduated 895 males and 146 females.

The problem also exists for minorities. In 1982, average SAT scores for blacks nationwide were 117 points lower than those for whites on the math portion of the test. In Ohio, the statistics are similar, with blacks in 1985 averaging 403 on math compared with 512 for whites. There is no science section in the SAT.

This education gap becomes a crevasse as women and minorities move into the workplace.

The U.S. Department of Labor predicts that 50 percent of the new jobs in upcoming years will require mathematics. If females and minorities aren't skilled in mathematics, they'll be cut out of those jobs.

FOR FOUR years, the Ohio Education Department has attacked the problem by holding workshops for teachers, counselors and administrators; by publicizing the inequities; and by support of private groups working on the issue.

At the workshops, participants are taught to notice subtle biases in textbooks, such as the constant depiction of scientists and engineers as white males. Posters, filmstrips and other materials are introduced that show minorities and females in technical roles.

Educators also are taught to recognize their own biases, and shown ways to encourage minorities and females to pursue more math and science.

"We're trying to get girls as turned on to computers as boys are," Bandy said. "I think there's been a growing awareness of the problem which has helped."

A department brochure concludes, "Once again, the schools are becoming a breeding ground for a pattern of opportunity based on sex, race and class — rather than on ability."

It points out that boys outnumber girls by nearly 2-to-1 in computer science courses. In addition, 80 percent of the high school students training to be video display terminal operators, data processing operators and other "low-paying, dead-end high-tech jobs" are girls, the brochure says.

BANDY'S BIGGEST concern, however, isn't for teachers. She believes the change must come at home, where attitudes about female roles are shaped.

"We have to help parents understand that it's just as important for little girls to have chemistry sets and microscopes as it is for little boys," she said. "The most important thing is building an attitude that all children need exposure to math and science."

The department encourages districts to meet with parents and convince them that upper-level math and science courses are important for females and minorities. It also has put together a booklet for parents on ways to encourage children's natural curiosity about math and science.

Those and other materials distributed by the sex equity office are available through some local school districts and through the department by calling 462-6244.

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BREAKING WITH TRADITION

BACK TO BASICS

Dispatch photo by Fred Squillante

Brandon Berry, 5, looks at a chrysalis — the stage before a butterfly emerges — during a Springfield science class

Springfield schools throw away the book

Science textbooks have been banned in Springfield City Schools' elementary and junior high science classes.

Last year, the 12,000-student district became the first in the state to begin a completely hands-on science curriculum for students in kindergarten through eighth grades. No textbooks are used, either as supplements or as daily guides.

Instead of "The Book," students learn from "The Box," a container filled with all the paraphernalia the class needs to learn science. Each teacher gets one of the boxes every few months, with the contents tailored to the class being taught.

INSTEAD OF reading about the human skeleton in the sixth grade, for example, students take apart an owl pellet, the mass of bones and other body parts owls regurgitate after swallowing their prey. The sixth-graders sort through the pellet and reassemble the animal skeleton, learning the names of the bones as they go along and comparing them with a human skeleton.

John Bartley, Springfield science supervisor, expects that students will do 650 to 800 experiments by the time they finish eighth grade under the new curriculum. Nearly everything they do is an experiment, from the sorting of seashells in kindergarten to the first-graders' observation of the eating habits of birds.

Under the previous textbook curriculum, students usually did only a handful of experiments during those nine years.

Bartley started the new program because he found science instruction lacking in elementary classes.

"SCIENCE WAS generally taught on Friday afternoons — if they didn't have an assembly or fire drill," he said.

Most elementary teachers felt uncomfortable teaching it, so little was taught.

Now, science instruction gets 90 minutes a week in the lower elementary grades, 120 minutes in the upper elementary classes, and 200 minutes a week in grades seven and eight.

The new program is being phased in, three grade levels at a time. Teachers get two weeks of training before they begin using the new approach in their classrooms. The training, at Wittenberg University, is paid for by the National Science Foundation.

Although the program hasn't been operating long enough to gauge its results, students and teachers are enthusiastic, convincing Bartley that the change is for the better.

LAST YEAR, 90 percent of the fifth-graders taking hands-on science volunteered to stay after school if that was the only time the program was offered.

"Something right is happening when I walk down the hall and two girls are talking about their mystery circuit boards rather than boys and Bruce Springsteen," he said.

Initially, the program costs more than a textbook curriculum, but there are long-term savings. Bartley figures the new curriculum costs $15 per student the first year, and $3 a year thereafter.

This compares with prior textbook costs of $11 to $16 for each student every five years, plus $2.50 each year for a workbook.

"Outside of the personnel costs, over the long haul it's no more expensive than textbook courses," he said. "And the greater involvement of the kids makes up for any extra costs."

THE SPRINGFIELD school board faces a huge deficit and possible staff layoffs. Nevertheless, members had enough confidence in the program to continue it for three more years.

Bartley said that about 20 other school districts nationwide have similar hands-on science programs; one in Illinois has been operating about 15 years.

But while staffers from more than 30 Ohio school districts have visited Bartley's program, none has yet copied it completely.

"Sometimes I think the cost scares them off, or the logistics of sending the materials to each teacher every few months," he said. "And it takes 60-hour workweeks to crank the thing out."

BREAKING WITH TRADITION

At Westerville North, girls are making up for lost time

Ten years ago, only three girls took physics at Westerville North High School.

Next year's projected enrollment: 125 girls, 80 boys.

Girls at Westerville are making up for lost time and lost opportunities, thanks to physics teacher David M. Weaner. Weaner has made a personal campaign out of increasing the number of girls in Westerville physics classes.

"I GUESS you could say I'm trying to get the United States society kicked ahead 20 years or more," he said. "I've tried to convince counselors, teachers and the girls themselves that sciences and technical careers are not male-oriented, that there is no such thing as male or female jobs. Now the whole science department is of that mind."

Weaner started by urging counselors to place girls in physics and by urging girls in biology and chemistry classes to consider physics.

"At first I always got a wrinkled nose and a 'That's for guys' kind of reply," he said. But once he persuaded a few girls to take physics, more and more girls realized it wasn't a male bastion and signed up.

Weaner has found that girls outpace boys in physics.

"They seem to have better minds for working in abstract areas, while the men have a little more tendency towards concrete rationalization," he said.

In recent years, Westerville North has had two students — both girls — win regional science fairs, which allowed them to compete in the International Science and Engineering Fair.

Weaner uses those successes to motivate more girls to take physics.

"Nothing succeeds like success, so once you have one, you have to make her very visible," Weaner said.

The dramatic reversal at Westerville hasn't come easily.

"You really have to work on it, because there's a lot of subtleties in discrimination," Weaner said. "It doesn't just happen."

WEANER SAID his talks with other physics teachers have convinced him that Westerville is still an oddity in terms of the number of girls in physics classes.

"As far as the nation as a whole goes, I seriously doubt that there will be big changes for a long time," he said. "There's still a lot of talk about the ERA, but not a lot being done about it.

"I wear a button that says, 'If you can dream it, you can do it.' It's a General Electric slogan. It doesn't say, 'If you're a man, you can do it.'"

Dispatch photo by Tim Revell

Westerville North teacher Dave Weaner and the girls in his physics class

BACK TO BASICS

Dispatch photo by Jeff Hinckley

Peter Addington and Angelica Aguilar work problem at St. Joseph Montessori School

New fad in math is old trick

"Manipulatives" is the latest buzzword in math education.

They're nothing new. Actually, they may be as old as math itself. But their rebirth is one thing that may help revolutionize math education.

A manipulative is any physical object a student uses to understand math. It could be as simple as the marbles that first-graders line up on their desks to help with addition problems.

THE POINT is, said Steve Meiring, a math specialist at the Ohio Department of Education, that students can *see* that when they add two marbles to two marbles they get four marbles. They don't have to imagine the process in their heads.

It's akin to counting on your fingers.

Teachers and parents have always used manipulatives to help preschoolers and young children learn the basics of math.

But these hands-on tools usually aren't available in the upper grades, Meiring said.

"Manipulatives appear to be at a rudimentary level — almost like they're only for low-level math skills — but there's nothing wrong with a child learning to count on his fingers," he said.

"Kids have to visualize ideas, to have pictorial models, because that's how we begin to build so we can understand bigger problems. Even in high school, we don't lose the need to see things spatially."

MEIRING IS working to get more teachers to make manipulatives part of their math classes.

He demonstrates manipulatives in workshops for teachers and math supervisors and has developed materials about them he can send to teachers.

Meiring doesn't suggest that manipulatives replace textbooks. He believes the two can work hand-in-hand.

But he does urge teachers to dramatize the texts, especially in younger grades.

"What you have to recognize is that kids through the second grade use a lot of intuitive skills and need a lot of acting out," he said.

That means that learning-by-doing programs don't require a lot of new money. Although there are plenty of manipulatives that can be purchased, many are easily made by teachers or the students themselves.

ACCORDING TO recent studies, teachers in 1983 were using fewer hands-on teaching techniques than they did a decade ago, but things have improved since then. And because student teachers see less use of manipulatives, they don't learn how to use them either.

To change that, the Ohio Department of Education puts on an annual three-day conference where science teachers can practice experiments and other participatory learning techniques. The department also co-sponsors Project Wild workshops where teachers learn environmental education in a hands-on style.

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Ohio avoids teacher shortages — so far

Story by Kathy Gray Foster
Dispatch Schools Reporter

"Teacher shortage, teacher shortage" shout newspaper headlines as educators nationwide predict a dangerous deficit looming in the classroom.

Math and science teachers are particular targets of this gloom-and-doom scenario.

And indeed, some districts have begun importing teachers from other countries or hiring people who lack certification to teach to fill their classrooms.

BUT NOT in Ohio, says G. Robert Bowers, assistant state school superintendent. At least not yet.

"There's no question there's a teacher shortage in certain geographical areas and in certain subjects, but there isn't one here," he said.

While he admits the pool of graduating teachers in math and science has dropped sharply in recent years, he said there still are enough to go around, even in smaller, rural districts that often have trouble attracting teachers.

But Larry Shelt, president of the Science Education Council of Ohio, believes Ohio will face a severe shortage in certain areas of math and science, such as chemistry, physics and computer math.

"IT'S ALREADY difficult to find teachers in those areas," said Shelt, a chemistry teacher in Toledo.

"Those are the areas where industry is waiting to offer teachers $10,000 more than they're making to switch jobs."

He thinks the crunch will come within 10 years. Some educators predict that about half the teachers employed now will be retired by then.

Don Wilson, president of the Ohio Education Association, also is leery of Bowers' rosy predictions.

"He bases it on the fact that he thinks many people who are certified to teach and aren't teaching will return to teaching," said Wilson.

"But most of them are out of teaching because they're making more money in industry, and I just don't see why they'd be coming back."

LARRY CUNNINGHAM, Columbus Public Schools personnel manager, said the district has found that math and science teachers are "tougher to find and there are fewer to chose from," but he said there is an adequate supply.

He said that for the last three years he has hired a few more math and science teachers than needed at the beginning of the year to fill in if teachers leave at midyear.

The extra teachers work as long-term substitutes until openings come up.

"There is a lot of turnover in those positions, in part because math and science people have more opportunities in business and industry than some other teachers," Cunningham said.

OHIO HAS managed to stay ahead of shortages, partly because enrollment has been dropping — from a peak of 2.4 million students in 1972 to just below 1.8 million (about the same as in 1960) in 1986 and a predicted 1.6 million by 1995.

Department officials estimate that Ohio colleges must produce about twice as many graduates as there are openings for new teachers each year to avert shortages.

Only about half of graduating teachers go into teaching, on the average.

In 1987, for example, the department estimates 244 math teachers will graduate and Ohio classrooms will need 145 of those (about 45 percent of the total openings).

Although that doesn't quite meet the 2-to-1 ratio, department officials predict it is close enough so there won't be shortages.

The remaining 55 percent of openings will be filled by teachers re-entering the field.

The department estimates similar numbers in future years.

BUT AT the same time, the percentage of newly graduating teachers needed is growing.

In 1984 it was 30 percent; by 1986 it had crept up to 44 percent. Officials expect that to level off in the next few years, however, so that a shortage won't materialize.

They're trying to boost their odds with a new teacher loan program, which last year gave out $500,000 in state money.

BACK TO BASICS

Students studying to become math, science and foreign-language teachers can receive up to $5,000 a year for tuition under the program.

A percentage of the loan is forgiven for each year they teach the subject in Ohio.

THE PROGRAM also offers up to $15,000 in consolidation loans to students who graduate each spring and plan to teach shortage subjects.

OEA's Wilson said he questions why the education department sponsors a loan program if it doesn't anticipate shortages.

Shelt said the loan program isn't enough, however, because it helped only about 145 students the first year.

"The one thing that would avert a shortage is for salaries to be brought up," he said. "That's the one thing that's not being taken care of."

IF SHORTAGES develop, they probably would begin in Ohio's small towns and villages.

Nearly half of Ohio high schools — 346 — have less than 500 students, and 147 have less than 300.

Sometimes, those schools will have only one science or math teacher, who is expected to be an expert in all the sciences.

And often those schools don't have enough students or money to offer physics, calculus and advanced biology on a yearly or even biyearly basis, relegating their science and math teachers to daily diets of general science and math courses.

BOWERS SAID that persuading math and science teachers to teach in those schools is difficult because pay is often low and needs are high.

Rural teachers have to teach a variety of classes rather than concentrate on a few, as their urban counterparts do.

He hopes to begin experimenting with classes taught on television or perhaps on interactive videodiscs to give those small-school students more opportunities and provide teachers some relief.

Dispatch photo by Fred Squillante

G. Robert Bowers

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Students respond to science when they know what it's for

Scripps Howard News Service

LAKEWOOD, Colo. – Danny is on the cutting edge of American school reform, but he would never know it.

Danny, an eighth-grader at Lakewood's Dunstan Junior High, has never shown much interest in formal education.

He spends most school days in the back of the classroom doodling or goofing around, ignoring the teacher.

But something unusual happened to Danny last fall. He finished a homework assignment.

"LAST YEAR his major accomplishment was setting a chair on fire," said Bruce Hogue, the teacher who gave Danny an A.

"The assignment was to do a report, any kind of report, about the brown cloud," Hogue explained.

"This kid wrote a song about it and sang it on a rock video. It was the first homework assignment he's completed in two years. I got to him."

Danny may never excel in science, Hogue said, but at least he understands the cause of a major environmental problem that he and his neighbors will someday have to solve.

Hogue's success is one small victory in the nationwide battle to improve general understanding of science. His Jefferson County School District program has twice been cited by the National Science Teachers' Association as one of the best in the nation.

Colorado school officials, like their counterparts elsewhere in the country, are searching for better ways to teach abstract, technical theories to students who often have little interest in the subject.

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Jefferson County's applied-science program is a leader in the effort.

At Dunstan, Hogue uses a blend of science facts, social issues and unusual flexibility in the classroom.

In tackling the brown cloud, for example, Hogue starts with a traditional laboratory equipment demonstration that duplicates the air pollution in the classroom.

WHERE MOST lessons would end, Hogue is just beginning. He steps out of the science teacher's clinical realm to help students use science facts to draft legislation and find ways to finance solutions.

It is a noisy, inexact process that might cause more orthodox science teachers to throw away their mechanical pencils and hang up their lab coats for good.

"Math and science instruction used to be lock step, sit in your seat and keep your mouth shut," Hogue said "(Now), we don't focus on science and then tack on the application; we go straight to the application and use just enough science to make it understandable."

Hogue helped design the applied-science course after 11 years as a traditional mathematics teacher.

"I was always bothered by my own response when kids would ask me why this (math) was useful to them," he said. "I got tired of just telling them to trust me, that it would be worth it some day."

While considered "bonehead science" by many teachers, applied science has been endorsed by Secretary of Education William Bennett and other leaders.

IN MANY districts, the program is being expanded to include elementary schools, where teachers usually cover reading and simple arithmetic, but not science.

In a recent monograph on elementary-school reform, Bennett called traditional, lecture-style teaching dull.

He asked, "Is it any wonder that children's natural curiosity about their physical world turns to boredom by the time they leave grade school — and into dangerous ignorance later on?"

Public school officials apparently agree. Few weeks pass without a visit to Hogue's classroom by educators looking for ideas to replace science programs that, in many schools, have not been updated since the early 1960s.

Ronald Anderson, an education professor at the University of Colorado at Boulder, said most public school science courses devote only 5 percent of their time to application of science knowledge in relation to societal issues, career preparation or personal life.

ADVOCATES OF applied-science programs say that is not enough in a modern nation coping with acquired immune deficiency syndrome, acid rain and nuclear power.

"We're saying, let's teach science for life and living in a context that will give us a greater understanding of the world and what is happening to us," said Manert Kennedy, a University of Colorado professor and executive director of the Colorado Alliance for Science.

Retirees may help fill need

Associated Press

Retired scientists, engineers and military men would be ready and willing to teach science and mathematics in the public schools, according to a report on teaching as a second career.

The report, by the National Executive Service Corps, says 50,000 scientists and engineers retire from industry each year, many of them still in their 50s and nearly half of them under 63.

The American Federation of Teachers has been enthusiastic about the use of retirees as teachers. "We're all in favor of tapping any source of skills," said spokesman Laurence McQuillan.

The National Education Association, led by Mary Futrell, is more guarded in its endorsement. "People coming into teaching from other fields find they just can't walk into the classroom and expect to succeed without the necessary preparation and credentials," Futrell said last fall.

A survey found that more than 70 percent of future retirees would be interested in teaching in public schools.

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APPENDIX C:
Project Questions

SCIENCE/MATH REPORTERS' ASSESSMENT PROJECT

Questions

A benchmark is to assess changes in the past three years, covering legislation/activities since the release of *A Nation at Risk*, but the major points will revolve around the status of science/math education at the present and the probable status over the next few years (with three years as another benchmark).

Are there new state standards for students in these subjects? Has the content of instruction been improved as a result?

Are there new state standards for teachers?

Have there been any changes in teacher supply? Teacher training?

Has there been an increase in funding?

How have new federal funds been used?

What percentage of teachers in these subjects have been "misassigned"?

What are assessment results (over three or more years)?

What is the involvement of the business community in improving math/science?

Any innovative programs? How is technology being used?

Any increase in local/state focus on math/science, e.g., task forces, studies?

What is the condition of equipment, textbooks, other resources?

How much emphasis is put on hands-on discovery methods in teaching versus textbook teaching?

What are the predictions/projections over the next three years (teacher supply, enrollment in courses, new funding, student achievement)?

What are the barriers to improved science/math instruction (e.g., Colorado is having trouble over textbook censors)?

Do any differences exist in offerings, resources, teacher supply and achievement levels among urban, suburban and rural districts?

Do enrollment patterns, achievement indicate any problems with access/instruction for minorities and females?